Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

RESERVE
aTD224
.C6A5

United States Department of Agriculture

Soil Conservation Service

Economic Research Service

Forest Service

Denver Colorado

Arkansas River Basin Cooperative Study Report

AD-33 Bookplate
(1-63)

NATIONAL
AGRICULTURAL
LIBRARY

24500

ARKANSAS RIVER BASIN REPORT

Cooperative Study

U.S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY
SEP - 7 1982
CATALOGING = PREP.

Colorado Water Conservation Board
and
UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service
Forest Service
Soil Conservation Service

773539

ARKANSAS RIVER BASIN REPORT

Table of Contents

Page

List of Tables

List Of Figures And Plates

PREFACE

The State of Colorado, through the Colorado Water Conservation Board (CWCB), requested the U.S. Department of Agriculture (USDA) to participate in a cooperative river basin study of the Arkansas River Basin in Colorado by letter on February 8, 1977. The objectives of this study are to identify resources, determine needs, and present alternative solutions to assist decisionmakers in the orderly development of water and related land resources of the area.

USDA participation in the cooperative river basin study is authorized under Section 6, Public Law 83-566, as amended. Authorization for the study as described in the study plan was given on June 25, 1979. The principal USDA participants are the Soil Conservation Service (SCS), Economic Research Service (ERS), and the Forest Service (FS). The Colorado Water Conservation Board also participated in the study.

The Colorado Field Advisory Committee (FAC) composed of representatives from the SCS, ERS, FS and CWCB provided the direction and overall management for the study. Study activities were carried out by personnel assigned from the various agencies as outlined in the Study Plan. Liaison with other state agencies was provided by the CWCB staff.

Additional information about the Arkansas River Basin Study should be requested from:

State Conservationist
Soil Conservation Service
P. O. Box 17107
Denver, Colorado 80217 (303) 837-4275

SUMMARY
ALTERNATIVES

The major focus of this study is to develop alternative solutions for 3 major concerns:

Irrigation Water Management
Water Erosion Control
Increased Water Yield

In addition, municipal water supply problems are identified for rural communities.

Irrigation Water Management

Under 1975 level of water supply and irrigation efficiencies, there is adequate water for only 20 percent of the crop needs. Numerous canal and on-farm irrigation systems need rehabilitating. Improvements in irrigation water management are also needed as a water conservation measure.

A basic objective of this study is to determine if it is economically feasible to upgrade these systems and make changes in managing the available water supply.

Initial investigations included an inventory of needs on 114 canals in the basin. This represents all of group canals with at least a 5 cfs diversion right for irrigation. These canals supply water to 400,461 acres of irrigated land. Detailed analyses were made on 46 systems serving 345,764 acres or 86 percent of the total irrigated acres inventoried.

Four alternative levels of improvement were analysed. They ranged from meeting all system needs to meeting only minimum structural needs, accompanied by management and land treatment measures.

At least one economically feasible alternative for improvement was found for 32 of the systems analyzed. These systems serve 313,000 acres or 90 percent of the irrigated lands studied in detail. Table S-1 includes data for only the selected 32 canal systems.

Plan A of table S-1 includes a combination of feasible alternatives that would tend to maximize net income. Plan B includes alternatives that encompass the highest level of improvement that is economically feasible.

We conclude that crop consumptive use, which translates into increased yields, would be increased by 15 percent above present conditions for plan A and 28 percent for plan B.

The economic analysis showes that greater net returns can be achieved, in this short water situation, by reducing the number of acres presently irrigated and changing cropping patterns to emphasize high value crops.

The 68 systems not analyzed in detail serve 54,697 acres of irrigated land and are located for the most part at relatively high altitudes. Hay and pasture are the principal crops grown. We expect that economically feasible alternatives could be developed in some of these systems; however, the success ratio will be much less than for those studied.

Further individual studies on specific canals could be done as follow-up feasibility studies, in accordance with interest by local units of government. Implementation policies other than USDA could produce additional potential projects.

Water Erosion Control

The water erosion concern deals with 15 critical water erosion problem areas that could be treated by project type action. Four land treatment levels were developed to show comparisons of certain approaches to conservation land treatment; (1) no project action; (2) land use management; (3) erosion and sediment control; (4) a combination of levels 2 and 3.

All levels considered would partially stabilize the eroding areas and reduce sediment yield. A comparison of effects between these levels of improvement is shown in Table S-2. The present rate of soil loss by sheet and rill erosion for the 420,700 acres studied, ranges from 1 ton to 12 tons per acre per year. The average soil lost to streambank and gully erosion is 2 tons per acre per year with about 47 acres of land lost from agricultural production.

The most complete treatment (level 4) would reduce gully and streambank erosion by 80 percent and reduce the area of critical sheet and rill erosion by 88 percent.

Municipal and Industrial Water Supplies

The M&I water concern deals with water supply problems experienced by communities with populations less than 5,000 people. The quantity of water available to those communities investigated is generally adequate to meet present needs except for 6 communities. From a water quality standpoint, 31 communities in the Eastern part of the basin have problems. There were no alternatives developed for this phase of the study because of the detailed nature of needed investigations. The primary emphasis was to identify significant problems, see Tables I-5 and I-6.

Increased Water Yield

The irrigation water management phase of this study showed that water supplies are inadequate to meet the basin demands. This is reflected in the extent of water shortages to crops shown in Table S-1.

Three types of activities can be considered as a means for developing increased water yield from watersheds; (1) weather modification or precipitation management, (2) blowing snow management, and (3) vegetation management.

Table S-1 -- Irrigation System Characteristics Impacted By Alternative Treatments
Arkansas River Basin, Colorado

Characteristics Impacted	Unit	Present Level	Plan 1/ A	Plan 1/ B
Acres 2/				
Present	AC	313,087		
Adj. Ac. to optimize net return 3/	AC	231,110	236,593	241,608
Water supplies are insufficient 4/				
Full water supply	AC	46,762	51,256	63,771
Short water supply	AC	266,325	185,337	177,838
CIR shortage	AF	490,278	330,736	316,512
Poor irrigation water management				
Canal seepage	AF	276,531	259,089	240,252
On-farm losses	AF	268,986	268,653	271,778
System irr. eff. (convey/on-farm)	%	51/31	54/34	57/36
Poor quality irrigation water 5/				
Salt in Surface Return Flows	Tons	101,951	98,579	97,886
Salt in Ground Water Recharge	Tons	1,145,984	1,101,817	1,053,126
More Beneficial Water Use				
Crop Consumptive Use	AF	121,523	139,334	155,046
Phreatophyte-Wetland Evapo Transp	AF	92,981	92,981	92,013
Return flows				
Total surface return flow	AF	51,779	50,089	49,081
Net ground water recharge	AF	294,229	278,117	264,901

1/ Table values are a summary of canal system data. Plan "A" tends to maximize net income and Plan "B" includes all economically feasible measures.
2/ Data for present condition based on 313,087 ac, under 32 canal systems.
3/ Adjusted acres (adj. Ac.) includes an allowable shift in cropping pattern from an increase of up to 10 percent for any given crop acres to a decrease of up to 40 percent. This shift is dependent on an increase in net returns.
4/ Based on 560,500 A.F. diverted in 1975, and 106,600 A.F. pumped. CIR=Consumptive Irrigation Requirement.
5/ Salt concentrations assumed identical for present level and both plans.

Blowing snow management and vegetation management in mountain areas have potential for increasing water yield to streamflow. Selected levels of development and management were assumed for purposes of estimating the potential for water yield increases. This information is shown in Table S-3 The greatest potential for these activities is on National Forest lands, however, more detailed studies should be used for site specific implementation. Forest Service planning activities at the National Forest level contain detailed information in regards to all forest resources, including potential water yield.

Table S-2 -- Effects of Conservation Treatment on 15 Critical Water Erosion Problem Areas
Arkansas River Basin, Colorado

	Units	Present	Level 1	Level 2	Level 3	Level 4
Water Erosion						
Gullies & Streambank	Tons/Yr	867,800	791,000	730,800	367,300	174,400
Sheet & Rill	Ac/Yr	64,900	55,200	44,400	48,400	7,900
	Tons/Yr	124,800	113,400	102,400	99,300	62,600
Land Voiding	Ac/Yr	46.9	42.8	39.5	19.4	9.6

Note: Description of various levels of treatment given on page II-7.

Table S-3 -- Water Yield Increase Potential Resulting From Vegetative and Blowing Snow Management Treatments

Item	Units of Measure M=1000's	Patch Clear Cuts Reach 11	Patch Clear Cuts Reach 12	Brush land Treatment Reach 11&12	Snow Fence Construction Reach 11	Snow Fence Construction Reach 12
Treatments						
Forest Clear Cut	M Acres	33	23			
Brushland Conversion	M Acres			54.5		
Snowfence Construction	Miles				339	71
Water Yield Increase, Total	M Ac. Ft.	51.8	136.0	73.3	194.4	104.0
Average Annual Costs	M $	20	104	301	263	55
Average Annual Benefits	M $	32	66	49	100	53
Benfits/Costs Ratio	No:	1.6	0.6	0.2	0.4	1.0

Note: See plate - "Irrigation Systems Inventoried" for location of reaches.

IMPLEMENTATION

A number of programs are available to assist land owners in implementing conservation practices and proper land and water use. On private lands, the assistance available includes the Conservation District program, Small Watershed Program, Great Plains Conservation Program, Cooperative Forestry Assistance Act, Resource Conservation and Development Program, Rural Clean Water Program, Agricultural Conservation Program, and FHA Loan programs.

These programs provide cost sharing incentives, technical assistance, and other means needed to deal with the four major concerns of this study.

On Federal lands, a variety of land management programs can be used to enhance, and be complementary to, the watershed development objectives. For example, the Forest Service can use the authorities in the 1897 Administrative Organic Act, Multiple Use - Sustained Yield Act, and National Forest Management Act to implement projects of resource development and water yield augmentation.

Federal programs other than USDA that are active in the basin include;

Bureau of Reclamation "Fryingpan-Arkansas Project"

Corps of Engineers "Fountain Creek Flood Control Project"

U.S. Geological Survey continuous studies relating to a Ground Water Network program, and the maintenance of streamgage stations.

A number of state agencies have on-going programs that also impact the concerns of this study. A more detailed account of these programs is given in chapter 3 of this report. The agencies involved include;

1. Colorado Water Conservation Board - which is the policy making and water planning agency in all matters concerning intra and interstate water development, conservation and management.

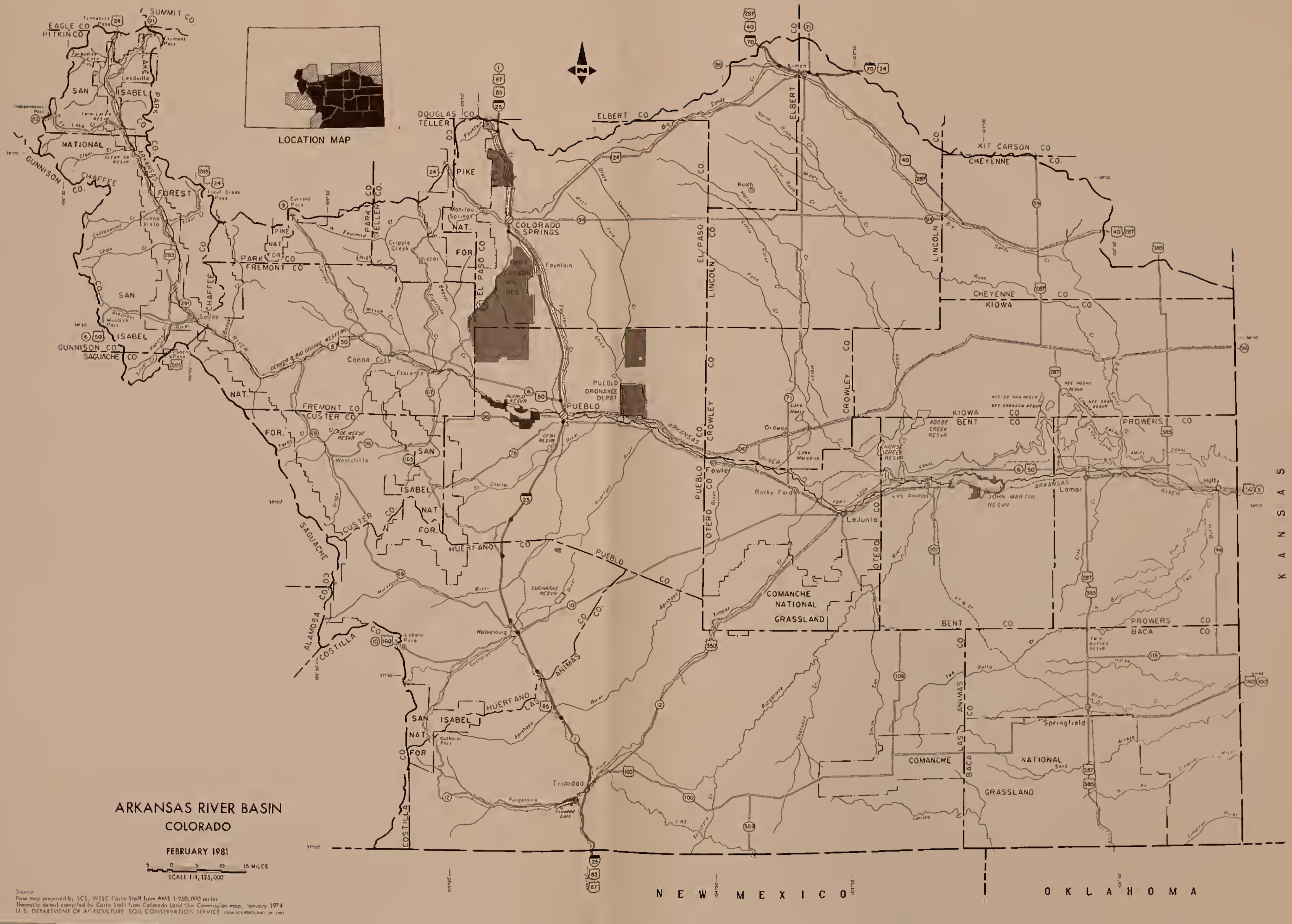
2. Colorado Division of Water Resources - responsible for administering the water supply of the state.

3. Colorado Geological Survey - engaged in programs relating to the geology and groundwater of the state.

4. Colorado Division of Parks and Outdoor Recreation - involved in activities related to outdoor recreation areas.

5. Colorado Division of Wildlife - responsible for managing the wildlife and its environment.

6. Colorado Water Quality Control Commission - responsible for programs involving water quality protection.



LOCATION MAP
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
5 0 5 10 15 MILES
SCALE 1:1,125,000
Source
Base map prepared by SCS, WTSC Carto Staff from AMS 1:250,000 series
Thematic detail compiled by Carto Staff from Colorado Land Use Commission map, January 1974
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
PUEBLO
COLORADO SPRINGS
FORT CARSON MIL RES
PUEBLO ORDNANCE DEPOT
COMANCHE NATIONAL GRASSLAND
SAN ISABEL NATIONAL FOREST
PIKE NAT. FOR.
Leadville
Salida
Canon City
Florence
Fountain
Limon
Ordway
Fowler
Rocky Ford
La Junta
Las Animas
Lamar
Holly
Springfield
Walsenburg
Trinidad
Westcliffe
Cripple Creek
Victor
JOHN MARTIN RESVR
PUEBLO RESVR
ARKANSAS RIVER
NEW MEXICO
OKLAHOMA
KANSAS

CHAPTER I - PROBLEMS AND CONCERNS

INTRODUCTION

The USDA River Basin Planning Staff began the Arkansas Basin Study with public meetings held in Lamar, Walsenburg, Pueblo, and Salida, Colorado. The meetings were to inform the public of the general conduct of the study and to solicit input regarding problems, desires and concerns. Thirty-six problems were identified at these meetings. The River Basin Planning Staff reviewed these and combined them into several categories.

Numerous studies have been completed or are underway in the Arkansas River Basin by various state and federal agencies. These studies deal with many of the problems identified in the previously mentioned public meetings. Therefore, it was agreed that this study would not address the same issues.

The study was directed toward the following problem catagories:

Irrigation water management
Quantity and quality of water supplies
Sheet, rill, gully and streambank erosion
Water supplies of rural municipal and Industrial Systems

It should be noted that Appendix A (Resource Base) generally deals with the entire basin, whereby other sections of this report deal with only selected areas. For this reason certain data, such as irrigated acres, may be different in Appendix A.

IDENTIFIED PROBLEMS

Irrigation Water Management

Irrigation water management is strongly related to the percent of irrigation water diverted into canals that is consumptively used by crops (irrigation efficiency). Included in the irrigation efficiency factor are (1) conveyance efficiency and (2) onfarm efficiency. The conveyance efficiency deals with the percent of water diverted that is delivered to farms, and the on-farm efficiency is that percent of water delivered to the farm that is consumptively used by crops. The product of the two is the system irrigation efficiency.

Historically, irrigation efficiencies in the West are low. It is not uncommon in the Arkansas Basin for individual systems to have efficiencies less than 40 percent. This means that 60 percent of diverted water is lost to the crops. There are several factors that contribute to this:

1. Insufficient and irregular seasonal distribution of water supply

2. Inadequate physical facilities to manage the water supply efficiently, both in the conveyance systems as well as on the farm

3. Lack of understanding and/or incentive, on the part of water users, to apply the amount of water most conducive to crop production

4. Inadequate or insufficient land treatment measures necessary for uniform application of irrigation water and, where necessary, drainage

An inventory and analysis was made specifically for this study, to identify and quantify problems and needs associated with canal and related onfarm irrigation systems. A typical problem encountered is discussed in an Engineering Consultants Report (1976) on seepage rates in the Ft. Lyons Canal. The report concludes that a seepage rate of 0.56 cfs per mile exists at a canal flow of 165-175 cfs. It was estimated that when the canal is delivering water to irrigators at the lower end of the canal, losses are in the neighborhood of 50-60 cfs. This implies a 32 percent loss or a conveyance efficiency of 68 percent. Other data on laterals to the Ft. Lyons canal show seepage losses of 2 to 11 cfs per mile.

Dense Vegetation along
Canal Restricts Flow

Table 1-1 is a summary of needs related to 114 irrigation canal systems inventoried as they exist at the present time (see plate - Systems Inventoried). Forty six of these systems were selected for further analysis in regards to possible project action. These 46 systems comprised the majority of surface irrigated croplands in the basin. Fourteen of these canals showed rehabilitation to be economically infeasible. The remaining group of canal systems (32) is the basis for the irrigation water management phase in Chapter 2. The present level of selected irrigation system characteristics for this group of canals is shown in Table 1-2.

The conveyance and on farm efficiencies used in this study are for a single canal system and do not reflect potentially higher efficiency values that might be used in a broader analysis where sequential use of return flows is considered.

In the Arkansas Basin, canal seepage, onfarm percolation to groundwater, and surface return flows from a specific canal system contribute to the water supply of downstream systems. For this reason, low irrigation efficiencies for individual systems do not necessarily reflect the basin-wide efficiency. In some cases, improvements to a canal system that increase efficiency of water use by crops, also reduce return flows. This subsequently impacts downstream diversions which, in effect, transfers water use from downstream systems to the system improved. In actuality this is true for only that portion of system losses that have historically reached

Table I-1 Irrigation System Needs (Summary)
Arkansas River Basin, Colorado

System Need	Unit	Amount Needed 1/	2/
Canal			
Cleaning	Miles	86.2	18.0
Lining	Miles	389.5	179.0
Pipeline	Miles	104.85	55.9
Diversion Structure	No.	45	16
Water Cont. Str.	No.	2,182	873
Onfarm			
Ditch Lining	Miles	1564.8	1174.
Pipeline	Miles	1977.25	1473.
Water Cont. Str.	No.	9,369	6891.
Land Leveling	Ac	122,019	16590.
Drainage	Ac	33,245	30825.
Irr. Water Mgt. 3/	Ac	400,461	313118.
Number of Systems Studied	No.	114	32

1/ Data for 114 canal systems inventoried.
2/ Data for 32 canal systems having viable alternatives.
3/ This is a non-structural practice involving improvements such as:

Irrigation scheduling
Time of irrigation set
Optimum stream size
Tailwater management
Minor irrigation method change
Maintenance of ditches and canals

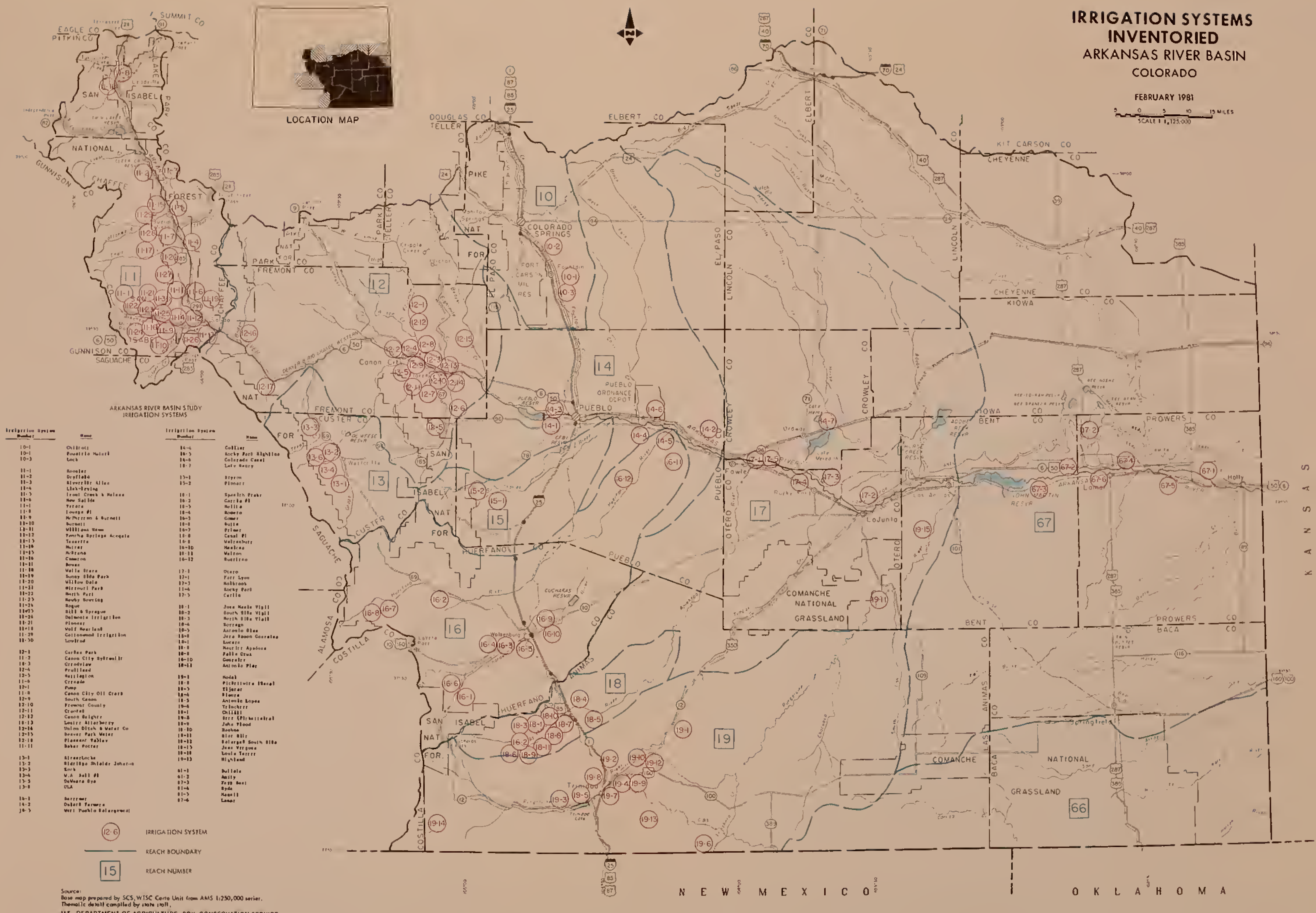

IRRIGATION SYSTEMS
INVENTORIED
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
LOCATION MAP
ARKANSAS RIVER BASIN STUDY
IRRIGATION SYSTEMS
IRRIGATION SYSTEM
REACH BOUNDARY
REACH NUMBER
Source:
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
Thematic detail compiled by state staff.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
COLORADO SPRINGS
PUEBLO
PUEBLO ORDNANCE DEPOT
COMANCHE NATIONAL GRASSLAND
NEW MEXICO
OKLAHOMA
KANSAS

TABLE I-2 Irrigation System Characteristics 1/
Arkansas River Basin, Colorado

Characteristic Impacted	Unit	Present Level
Acres		
Present	Ac	313,087
To optimize net return 2/	Ac	231,110
Water Supplies Are Insufficient 3/		
Full water supply	Ac	46,753
Short water supply	Ac	266,328
CIR shortage	AF	490,278
Poor Irr. Water Mgt.		
Canal seepage	AF	276,531
On-farm losses	AF	268,986
System irr. eff. (convey/on-farm)	%	51/31
Poor Quality Irr. Water		
Salt in Surface Return Flows	Tons	101,951
Salt in Groundwater Recharge	Tons	1,145,984
More Beneficial Water Use		
Crop Consumptive Use	AF	121,523
Phreatophyte-Wetland Evapotranspiration	AF	92,981
Return Flows		
Total surface return flow	AF	51,779
Net ground water recharge	AF	294,229

1/ For 32 systems having economically feasible alternatives
2/ Acres generated by the basin computer model
3/ Based on 560,500 A.F. diverted, and 106,600 A.F. pumped in 1975.
CIR = Consumptive Irrigation Requirement.

Canal Diversion
Structure Needed

On-Farm Water Control
Structure Needing
Replacement

Dense Vegetation
Along Farm Irrigation
Ditch Restricts Flow

downstream users. That portion of losses that goes to incidental uses, such as phreatophytes, wetlands, out-of-basin groundwater, etc. can be salvaged for crop use without impacts to downstream irrigation water rights.

A review of agricultural related benefits of irrigation system improvements include reduced labor and operation and maintenance costs in managing irrigation water, greater crop yields that result from increased water availability, more efficient use of fertilizers resulting from a reduction in leaching, and reduced salinity in return flows. The extent of improvements investigated along with related impacts are discussed in Chapter 2 of this report.

Water Supply

Specific problems associated with irrigation water supplies are:

1. Insufficient water to meet crop needs.

2. The timing of the available water supply is not optimum to crop demands.

Diversions and pumped groundwater amounts were determined for selected canal systems in the basin (for 1975). These values were used in a supply-demand analysis to determine the extent of water shortage. Several irrigation system improvement schemes were developed and analyzed, in conjunction with the water supply, to determine their impacts to the agricultural economy. Parameters chosen to reflect the water supply are as follows (see Table 1-2):

1. Acres with full water supply.

2. Acres with short water supply.

3. Water shortage.

Table I-2 shows that crop consumptive irrigation requirements exceed the available water by 490,000 acre feet, for 1975 water supply conditions.

Figure I-1, from another study, shows a monthly distribution of water supply, requirements, and resulting shortage for the Arkansas Valley between Pueblo and the state line. This is representative of data shown in Table I-2 and is shown here for the purpose of illustrating the seasonal problem. The water shortage problem may be somewhat less in magnitude at the present time as a result of such additional storage facilities as Pueblo and Trinidad Reservoirs, however, shortages remain a major problem.

Numerous reservoirs exist throughout the basin for the purpose of improving seasonal distribution of the water supply. These facilities provide carry-over storage from wet years, as well as seasonal carry-over from spring runoff to peak demand periods in mid summer. The problem associated with this is that there is insufficient storage to even out the

extreme variability of streamflow from year to year and month to month. As an example, records for one major canal in the basin show a maximum diversion of 393,500 acre feet, a minimum of 100,700 acre feet, and an average of 218,200 acre feet during the period 1950 to 1966. This same canal shows an average flow of 36,400 acre-feet in June and 27,400 acre-feet in July. The demand in June is considerably less than for July which illustrates a common problem of insufficient seasonal storage to match supply and demand.

Pueblo Reservoir provides
Regulation of Irrigation Water

Groundwater from the valley fill aquifer has been developed for the purpose of supplementing surface water supplies. This development became quite extensive during the 15 year period of 1950-65. However, since 1965 there has been a substantial reduction in the rate of well installation. Figure I-2 illustrates the rate of groundwater withdrawal for irrigation during the years 1940 to 1968, (more recent data is not available).

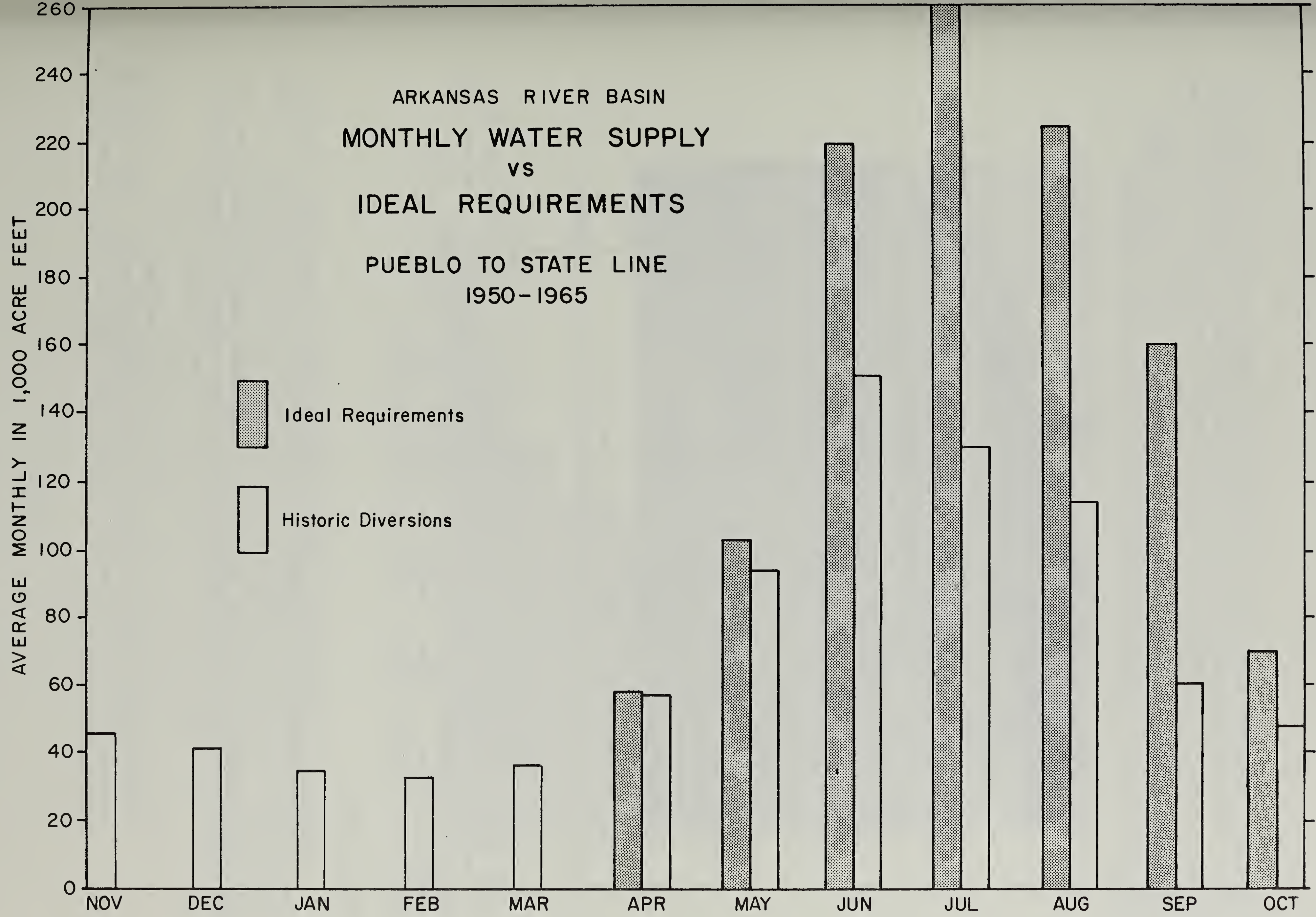
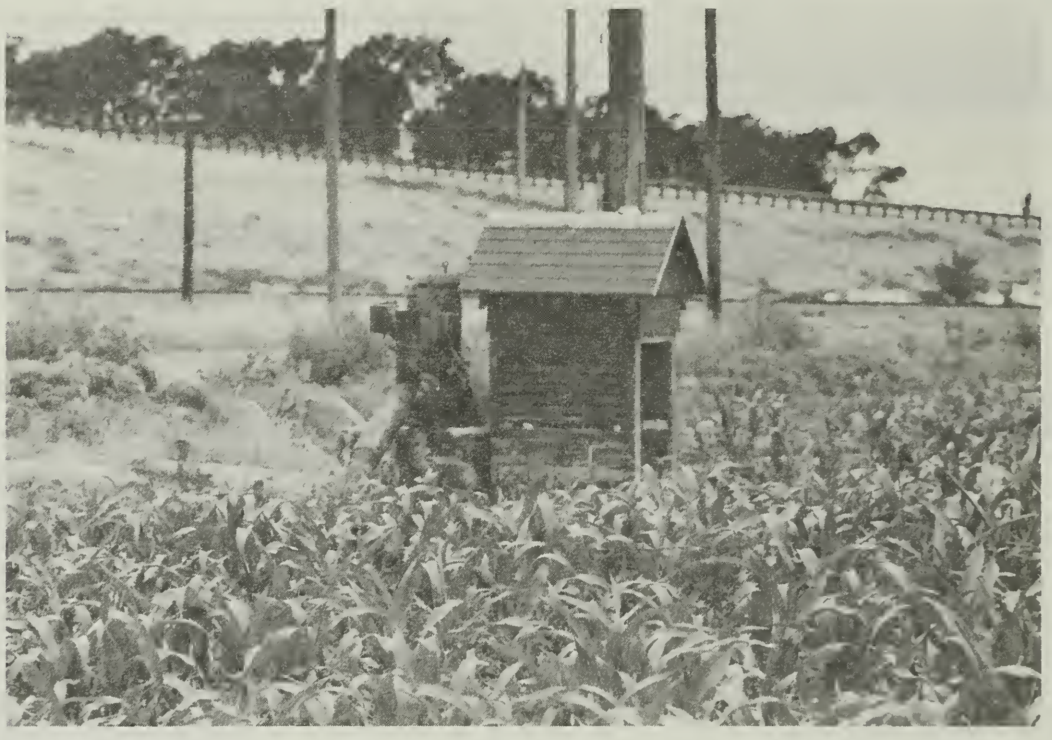


Figure I-1

Source: "Water Legislation Investigations for the Arkansas River Basin in Colorado" - W.W. Wheeler & Assoc., Woodward-Clyde & Assoc.

There are now about 3,000 large capacity wells between Pueblo and the state line. The problem associated with additional groundwater utilization is a matter of over-adjudication of the water supply. Groundwater aquifers that are hydraulically connected with surface streamflow must now be managed according to state surface water right requirements. The surface water supply is already severely over-adjudicated in the basin.



Well for Supplemental
Irrigation Water

Goundwater development may have already affected streamflow in the lower basin. A study by W. W. Wheeler and Associates, and Woodward-Clyde and Associates (1968) concludes that accelerated pumping during recent years has caused a decrease in surface flow available to water users. This suggests that more return flows from irrigation are possibly going to groundwater recharge rather than surface return flow.

Water Quality

According to information from the CSU Extension Service, the Arkansas River between La Junta, Colorado and Garden City, Kansas is the most saline stream of its size in the United States. They have estimated that agriculture contributes about 14 percent of the total salt load yielded by the Arkansas Valley and non-agricultural sources produce the remaining 86 percent. The primary effects of agriculture on water quality are:

1. Water is consumed by crops, phreatophytes, wetlands, etc. causing a concentrating effect of salts in the remaining water. More than 90 percent of the river water passing Canon City is consumed before it reaches the state line.

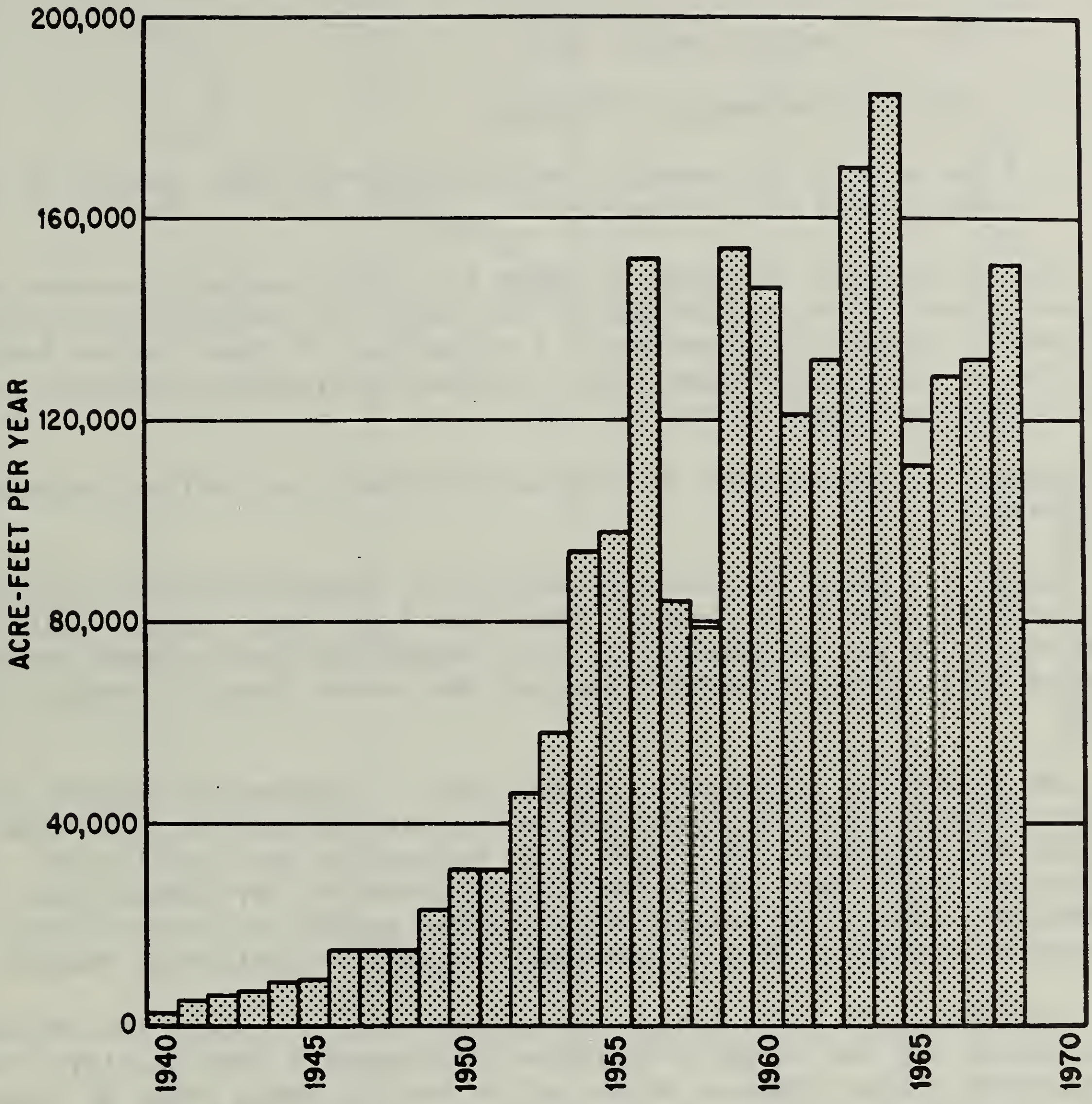


Figure I- 2 **Ground-water withdrawal by irrigation wells.**

Source: "Ground Water Basic-Data Release No. 21"–U.S. Geological Survey, 1970.

2. Irrigation return flows carry salts leached from the soil profile. This includes some fertilizer elements, as well as salts existing naturally in the soil, and subsurface aquifers.

Water quality information provided by this study includes:

1. Salt in surface return flow.

2. Salt in groundwater recharge.

3. Net salt to groundwater, which allows for salt removed in pump water used for irrigation.

This information is given in Table 1-2, which reflects average salt concentrations of about 1400 mg/l to 1600 mg/l for surface return flows and groundwater recharge respectively. A comparison of these values for present condition vs alternative conditions provides information on effects on water quality from potential projects.

Figure I-3 illustrates the degree of salinity at various locations in the basin.

Figure I-5 shows the general location of saline soils on non-irrigated and irrigated land in the basin. These are lands where marine shale formations are found in the substratum. The formations contain high levels of soluable salts which are easily leached when water comes in contact with the shale.

The quality of groundwater in the basin is determined largely by the aquifer in which water is contained and in part by bedrock formations that underlie the aquifers. The water is of moderately good quality in mountainous areas where the valley fill is underlain by igneous and metamorphic rocks. The quality deteriorates rapidly downstream from Canon City where the valley fill is underlain largely by Cretaceous shales.

Groundwater in the alluvium and terrace deposits along the Arkansas River Valley and its larger tributaries is generally poor quality. Along the mainstem of the Arkansas River and in certain shale areas in Pueblo, Las Animas, and Huerfano Counties, the water is of such poor chemical quality that domestic water is hauled in from neighboring communities having public water systems.

Table I-3 illustrates typical present level salinity in diverted water for selected canal systems in the basin.

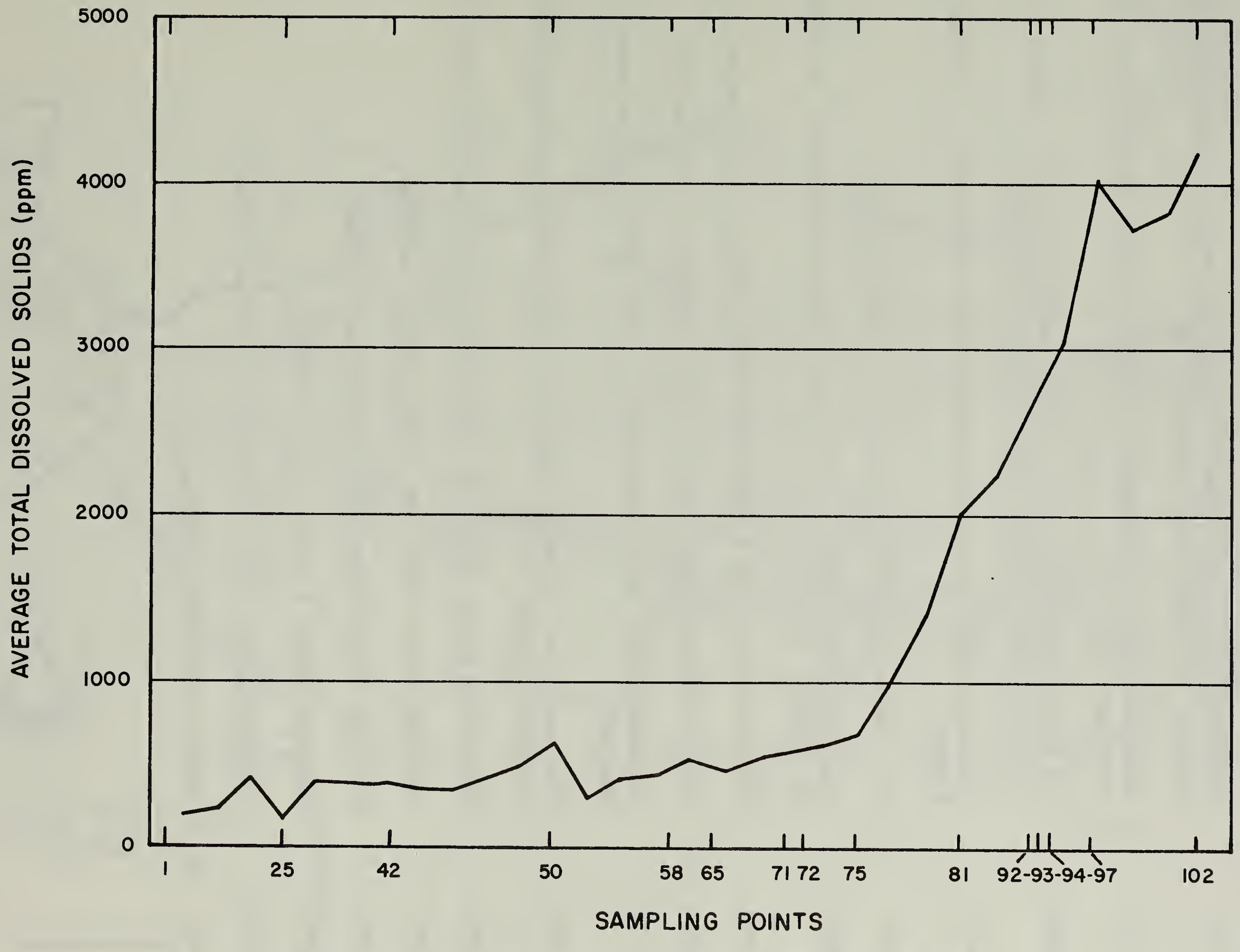


Figure I-3 SALINITY LEVELS IN BASIN STREAMS

Source: "Water Quality Survey of Arkansas River" - Colorado Dept. Health (1971-72)

SAMPLING POINTS

Number:	Location:
AR#1	Arkansas River approximately 10 miles west of Canon City at Highway 50 bridge near Parkdale.
AR#25	Arkansas River at Highway 67 bridge - above Florence sewage treatment plant.
AR#42	Arkansas River at gaging station west of Pueblo, approximately 1/2 mile below U.S.B.R. dam construction site.
AR#50	Fountain Creek at gaging station north of Pueblo at Highway 47 bridge.
AR#58	St. Charles River at Highway 50 bridge (RPS#86)
AR#65	Huerfano River above confluence with Arkansas River at Highway 50 bridge.
AR#71	Arkansas River 200 yards below Fowler sewage lagoons outfall.
AR#72	Apishapa River above Caflin Canal headgate at Highway 50.
AR#75	Arkansas River below Manzanola at Fort Lyon Storage Canal Headgate.
AR#81	Arkansas River at West edge of La Junta below confluence with Anderson Arroyo.
AR#92	Purgatorie River south of Las Animas at Highway 101 (RPS #10).
AR#93	Arkansas River below Las Animas sewage lagoons.
AR#94	Arkansas River below John Martin Dam spillway.
AR#97	Arkansas River 5 miles east of Lamar.
AR#102	Arkansas River south of Coolidge, Kansas (RPS#1).

Note: AR in Number refers to Arkansas River

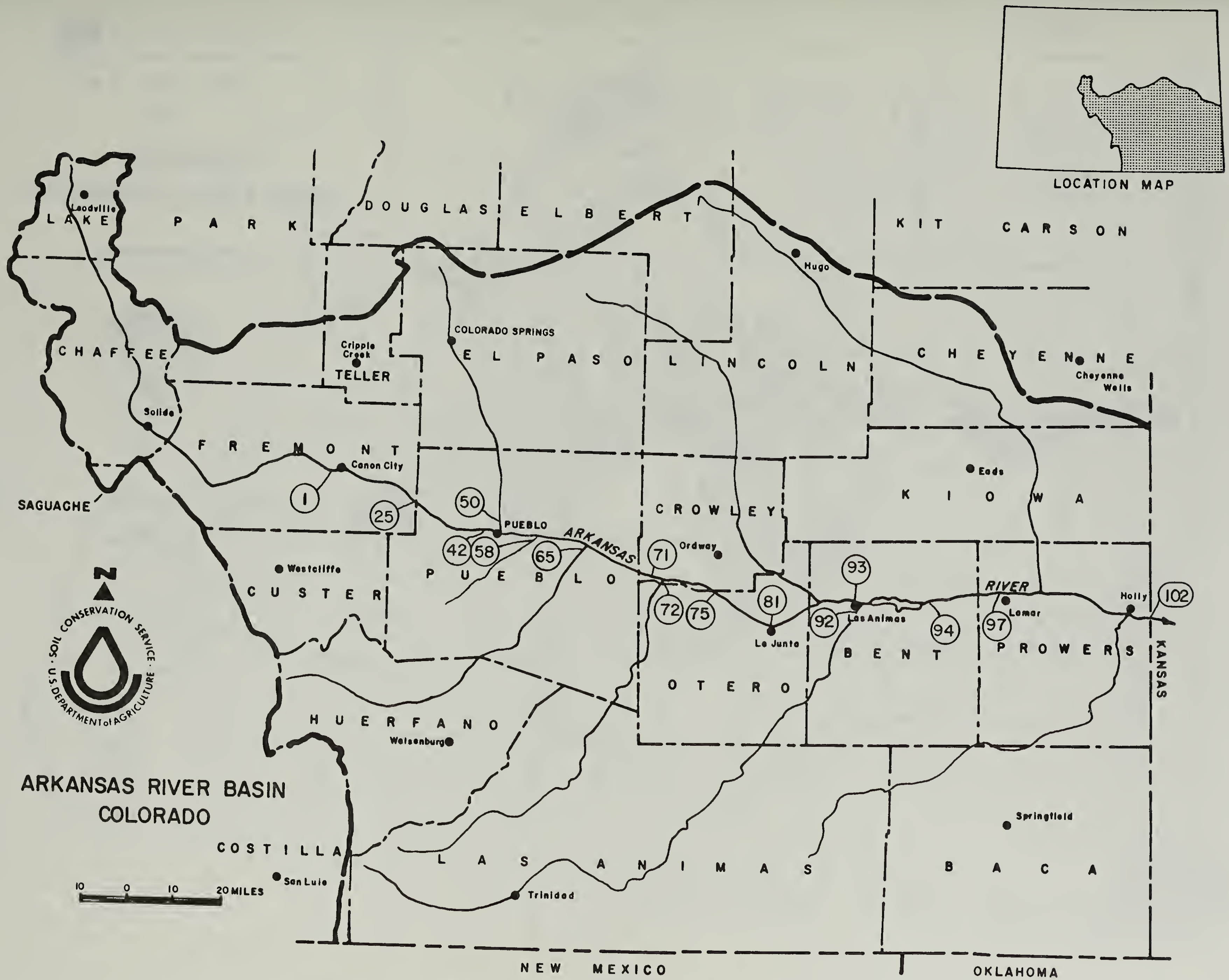


Figure I-4 LOCATION OF SAMPLING POINTS

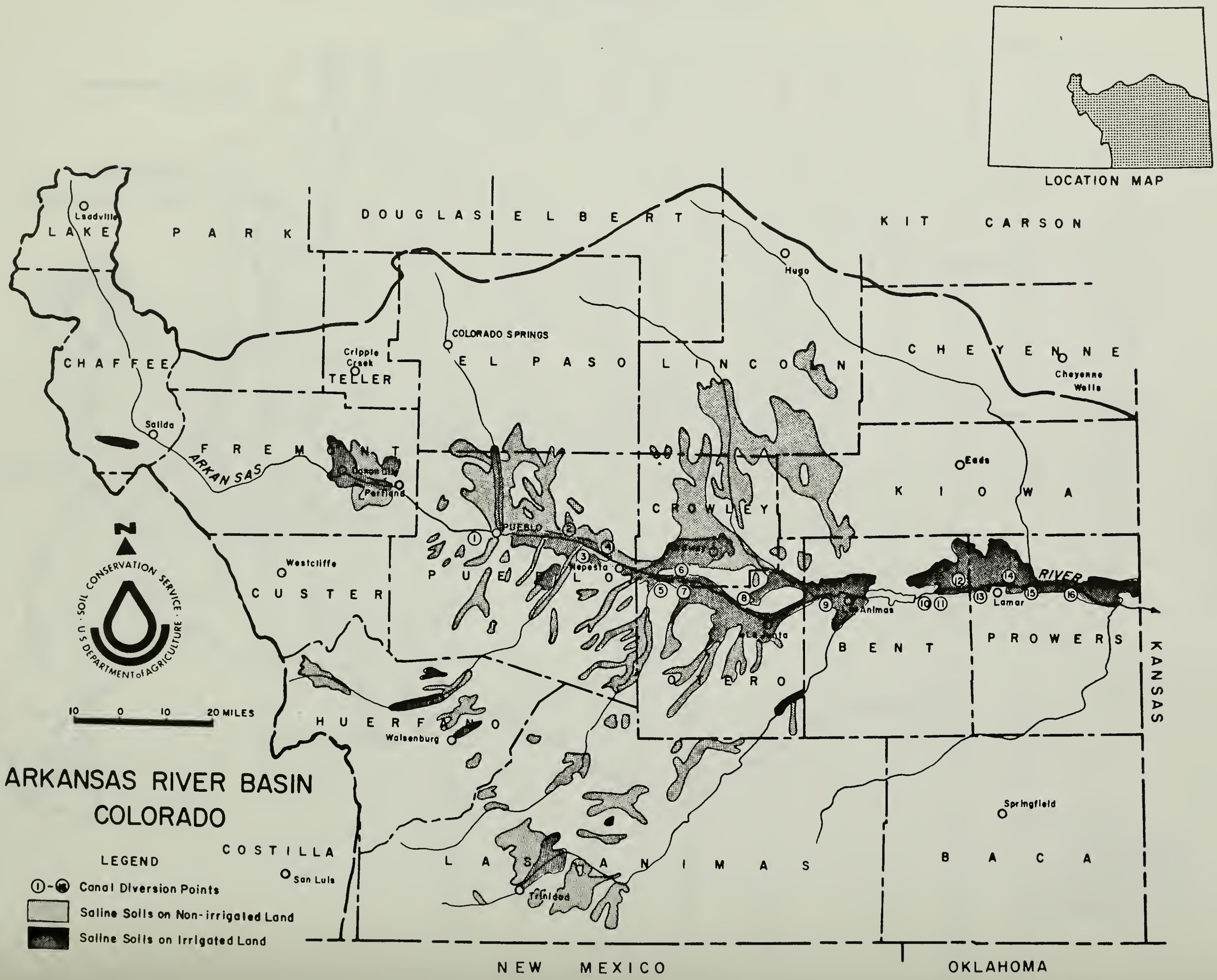


Figure I-5 LOCATION OF SALINE SOILS

Table I-3 Salinity Levels of Water Diverted by Canals East of Pueblo
Arkansas River Basin, Colorado

Canal	Irrigated Acres Served	Total Dissolved Solids (ppm) Volume Weighted Average	Maximum
Bessemer	20,000	300	770
Colorado	43,000	630	900
Highline	24,000	530	950
Oxford	6,000	500	960
Catlin	18,000	720	1,000
Holbrook	16,000	830	1,000
Rocky Ford	8,000	900	1,200
Fort Lyon	93,000	1,540	2,200
Consolidated	6,000	1,560	3,400
Fort Bent	5,400	2,200	4,300
Keesee	1,400	2,400	4,300
Amity	34,000	1,900	3,600
Lamar	6,000	3,000	5,100
Hyde	1,000	2,300	3,500
X-Y & Graham	4,000	2,100	3,600
Buffalo	3,600	3,000	4,700

Source: "Salinity in the Arkansas Valley of Colorado"
Cooperative Extension Service, Colorado State University (1977)

Water Erosion

Water erosion is an ongoing problem in the Arkansas River Basin. For the purpose of identifying critical erosion areas, evaluation teams composed of Forest Service and Soil Conservation Service personnel carried out the identification and survey of critical water erosion areas of the basin. The following criteria was developed for the identification of the areas: (1) boundaries must comply with the Colorado Hydrologic Unit Map - 1974; (2) sheet and rill erosion is considered critical when it exceeds the soil loss tolerances (T value); (3) active erosion with depths greater than 1.0 foot is considered critical streambank or gully erosion; and (4) there is landowner and public interest potential for a group project-type action. The selected areas for water erosion control meet the aforementioned criteria. Although there are other critical eroding areas within the Arkansas River Basin, they do not meet the above criteria.

Fifteen hydrologic areas were selected on the basis of existing local information. Watershed Investigation Reports (WIRs) were prepared, 12 on private land and 3 on National Forest lands. Table I-4 is a summary of the results of surveys made on the identified areas by counties. The evaluation teams made field surveys of sheet, rill, gully and streambank erosion by land use for each of the identified hydrologic areas. The Universal Soil Loss Equation (USLE) was used to determine the upland erosion in tons per acre that is presently occurring. The 15 critical water erosion problem areas surveyed, totaled 420,707 acres of the basin. The rate of sheet and rill erosion ranges from 1 ton to 12 tons per acre per year. Streambank and gully erosion is about 2 tons, per acre per year with about 47 acres of agricultural land lost. The USLE was also used to predict the amount of erosion that would occur as a result of applying certain combinations of land treatment to be described in Chapter II.

The Bureau of Land Management has identified Badger Creek area, Castle Gardens Gulch, and Four Mile Creek as critical eroding areas. Sedimentation and soil surveys are being conducted on these areas and will not be discussed in this report.

Municipal and Industrial (M&I) Water Supplies

Rural communities with population less than 5,000 people were the subject of investigation for this phase of the study. The investigation included a review of existing reports, plans, etc. prepared by local units of government, and state agencies. On-site field investigations were not made. At present most cities and towns in the mountainous area of the basin obtain their water supplies from surface water sources. Most communities east of Pueblo are dependent upon groundwater.

Complete data pertaining to the use of water for industrial purposes are not available for the basin, however, most smaller enterprises obtain their water supplies from municipal systems.

Gully Erosion

Streambank Erosion
and Sedimentation

Table I-4 Critical Area Erosion July 1980 conditions
Arkansas River Basin, Colorado

County	Critical Area Identified	Drainage Area (Acre)	Sheet & Rill Erosion (Acre)	Sheet & Rill Erosion Average (Ton/ac/yr)	Gully & Streambank Erosion 1/ (Tons per yr)	Total (Tons/ac/yr)	Average Land Loss 2/ (Acres per yr)
				Private Land			
Fremont	Cocklebur Creek	3,635	2,400	3.67	5.24	8.91	0.6
Pueblo	Steel Hollow	18,234	14,100	1.50	3.67	5.17	3.6
Pueblo	Fountain Creek	24,214	16,400	1.58	4.66	6.24	5.2
Pueblo	Airport Area	23,475	8,000	1.91	4.79	6.70	6.2
El Paso	Jimmy Camp Creek	42,240	10,300	1.98	0.77	2.75	2.6
Huerfano	South Oak Creek	21,160	700	2.57	1.32	3.89	3.4
Huerfano	Buckskin Flats	8,154	1,800	1.83	1.11	2.94	1.6
Pueblo	Kramer Creek	61,205	7,500	1.51	0.28	1.79	1.3
Las Animas	Burro Canyon	18,051	0	-	2.82	2.82	2.6
Las Animas	Mauricio Canyon	11,879	0	-	0.40	0.40	0.3
Las Animas	Frijole Creek	52,874	2,400	2.21	2.32	4.53	5.4
Custer	Custer County	122,198	0	-	2.33	2.33	14.0
	Subtotal	407,319	63,600				46.8
				National Forest			
Lake	Empire Gulch	3,892	300	8.0	0.00	8.00	0.0
Lake	Little Union Creek	3,736	600	11.6	0.01	11.61	0.0
Chaffee	Four Mile Creek	5,760	400	5.3	0.05	5.35	0.1
	Subtotal	13,388	1,300				0.1
	Study area Totals	420,707	64,900				46.9

1/ Tons of Soil Loss per acre per year computed by using total drainage area.
2/ Land destroyed by gullying and streambank erosion

The principal industries having individual sources of supply are the power companies, railroads, packing plants and canneries, sugar refineries, and the steel and iron works at Pueblo. Much of the water diverted by these industries, although essential to operation, is returned to the stream for subsequent use for other purposes. There are no major water supply problems associated with this segment of industrial water use.

From a chemical quality standpoint, the water supplies of communities located east of the foothills leave much to be desired. There are problems of the following nature - see Tables I-5 and I-6;

1. Filtration
2. Chlorination
3. Radioactivity
4. Contamination from leach fields
5. Selenium exceeds standard

Six communities studied have water supply problems of the following nature - see tables I-5 and I-6;

1. Inadequate system capacity
2. Inadequate yield from wells
3. Inadequate storage
4. Inadequate distribution system

Table I-5 M&I Water Supply Problems And Needs
Arkansas River Basin, Colorado

Problem-Need	Units	Total
M&I Water Requirements		
On-stream Communities	Ac ft/yr 1/ 3/	82,100
Off-stream Communities	Ac ft/yr 1/ 4/	16,394
Communities Identified With Inadquate Water Supply		
Number	No	6
Population	No	7,797
Quantity of Water Supplied	Ac ft/yr 1/	1,747
Systems Not Meeting State Water Quality Standards		
Filtration Problem		
Number	No	9
Population	No	15,103
Quantity of Water Supplied	Ac ft/yr 1/	3,383
Chlorinator Problem		
Number	No	8
Population	No	3,946
Quantity of Water Supplied	Ac ft/yr 1/	884
Radioactivity Problem		
Number	No	7
Population	No	2,910
Quantity of Water Supplied	Ac ft/yr 1/	652
Other Problems		
Number	No 2/	7
Population	No	7,100
Quantity of Water Supplied	Ac ft/yr 1/	1,590

1/ Based on an average requirement of 200 gallons per day per person or 0.224 Acre Feet per year per Person
2/ Problems include; (a) no Coagulation (pipe freeze)
(b) wells too close to leach field
(c) selenium exceeds Maximum Contaminant Level (MCL)
(d) nitrates exceed MCL
(e) high SO4
3/ 29-on-stream communities
4/ 61-off-stream communities

Table I-6 -- Communities with M&I Water Quantity and Quality Problems
Arkansas River Basin, Colorado

Community	Problem Description
Branson	Chlorinator broken; plant needs general upgrade.
Cascade	No filtration; surface source.
Cheraw 2/	Radioactivity exceeds MCL; no chlorine residual; corroded pipe.
Chipeta Park	No filtration; surface source.
Coal Creek	No filtration; surface source; old pipes, frequently freeze.
Crowley 2/	No chlorine residual; Radioactivity.
Eads	Selenium exceeds MCL 1/; inadequate fire protection; near capacity.
Eureka	Radioactivity exceeds MCL.
Fayette Water Co.	Radioactivity exceeds MCL; chlorinator not working; no filtration.
Florence	Proposed service to Coal Creek and Williamburg may tax capacity.
Granada	Radioactivity; low water table; old system needs upgrading.
Green Mt. Falls	Surface source; no filtration; high turbidity (beyond MCL).
Hasty	No chlorine residual.
Holly	Low chlorine residual; no filtration; packing in east well needs repair.
Johnson Village	Wells too close to leach fields (25').
Kim	Nitrates exceed MCL (15 mg/l); no filtration.
Las Animas	High SO_4 results in hauled water.
La Veta	Supply inadequate in summer-untreated water bypassed to meet demand.
Limon 2/	Pipes frequently freeze.
Manitou Springs	Needs filtration and clarification. Still has flouride problem.
Manzanola	Radioactivity exceeds MCL.
Olney Springs	Chlorinator malfunctioning.
O'Neal Water Supply	Selenium exceeds MCL.
Palmer Lake	Frequently suffers freezing pipes; no coagulation.
Parkville	Surface source; no filtration.
Pritchett	No chlorinator on new well; occasional unsafe bacteria.
Red Rock Valley Water District	Occasionally has inadequate supply for present user.
Rockvale	Shallow wells, septics.
Round Mt. Water & San. District	Poor storage and line capacity; seasonal shortage; no fire protection.
Starkville 2/	Chlorinator not functioning; no filtration.

Table I-6 (con't)

Community	Problem Description
Swink 2/	Radioactivity exceeds MCL; chlorinator malfunctioning.
Two Buttes	Wells not capped; chlorinator not working.
Walsh	Alternate well not chlorinated; existing chlorinator need enclosure.
Wetmore	Community well failed; no transmission lines, water hauled.
Wiley	Radium exceeds MCL; high alpha activity.
Williamsburg	Shallow wells, septics, no filtration, coagulation or sedimentation.
Woodland Park	Surface supply, no filtration.

1/ Maximum Contaminant Level (MCL)

2/ Since this study was initiated, these communities have resolved their respective problems.

Source: State of Colorado Document (November 28, 1980) by Water/Sewer Needs Coordination Committee Pertaining to Listing and Categorization of Local Water and Sewer Needs.

CHAPTER II - ALTERNATIVES
INTRODUCTION

A selected USDA Program plan was not developed for this study. Instead, this report shows 2 alternative plans and related impacts. This report will be supplied to potential sponsors and decisionmakers to assist in treating problems, and in the orderly development of water and related land resources.

The identified problems of Chapter 1 were treated as four individual categories. These are Irrigation Water Management, Water Erosion Control, Municipal and Industrial (M&I) Water, and Increased Water Yield from Watersheds. They are to be treated separately with each having its own alternatives (except M&I Water).

Preliminary investigations dealing with system problems were made on 114 canals which met study criteria of 5 cfs or greater water right. Forty six of these were selected for analysis in regards to possible project alternatives. The 46 included the larger systems in the lower basin and a selection of smaller systems throughout the basin to serve as representative samples.

The Water Erosion Control investigations identified 15 critical water erosion problem areas that could be solved by project type action. These problem areas are in, or close to, the foothills of the Rocky Mountains. There are 3 areas on the San Isabel National Forest land, and 12 on private lands.

The M&I Water investigations included communities and towns of 5,000 population or less. They were studied to determine present and future water quality and quantity needs.

Increased water yield from watersheds was studied in regards to vegetative management and blowing snow management. This was to further address the water shortage problem in the basin.

The alternatives addressed in this study were composed of various combinations and amounts of the following practices: canal lining, pipelines, diversion structures, water control structures, phreatophyte control, onfarm ditch lining and pipelines, land leveling, drainage, changes in irrigation methods, irrigation water management, erosion control, land use management, snow fences and vegetation management.

Irrigation Water Management

Alternatives for irrigation water management were developed and analyzed for 46 individual canal systems and associated onfarm systems. These alternatives were not preconceived toward any specific objective but were simply an array of different levels of improvement.

They included an alternative with measures designed to substantially meet each system's needs, as well as an alternative with only minimum structural practices and other measures compatible with environmental quality factors. Two intermediate alternatives completed the array. The next phase of study was to select economically feasible alternatives that would most nearly accomplish the following; (1) maximize net farm income - plan A, (2) provide the highest level improvement that is economically feasible - plan B. It was determined that plan B will also tend to maximize water use efficiency, preserve prime land, and improve water quality. The analysis showed that 32 of the 46 canal systems had at least one feasible alternative. The 32 systems represent 90 percent of those irrigated acres analyzed. Tables II-2, II-3, and II-4 are compilations of pertinent information for the 32 canal systems. Those alternatives that had a 0.75 or greater to 1.0 benefit cost ratio were considered economically feasible. It was found that for most individual systems only one alternative met this requirement. Therefore, in this situation the one alternative was included in both plans. For those canal systems that had several feasible alternatives, a choice was made designating the most appropriate alternative for each plan.

A summary of irrigation system needs is shown in Table I-1 in Chapter 1 for all canal systems inventoried as well as for the 32 systems having feasible alternatives. Table II-1 is a summary of practices comprising selected alternatives that went into the 2 plans. Tables II-3 and II-4 show various impacts and effects.

It should be recognized that implementation policies other than USDA, such as private financing, could produce an entirely different list of potential projects.

Water Erosion Control

This analysis involves the identification of 15 critical erosion areas and proposals for reducing erosion rates (see plate - Erosion Areas). Four land treatment levels were developed: 1) no project action or a continuation of the existing programs; 2) accelerated program of installing only land use management type practices; 3) accelerated program of installing only erosion control structures; and 4) accelerated program of installing resource management systems or a combination of land use management practices and erosion control structures. The rationale in the development of these alternatives is to show comparisons of certain approaches to conservation land treatment. Obviously, actual application would be a combination

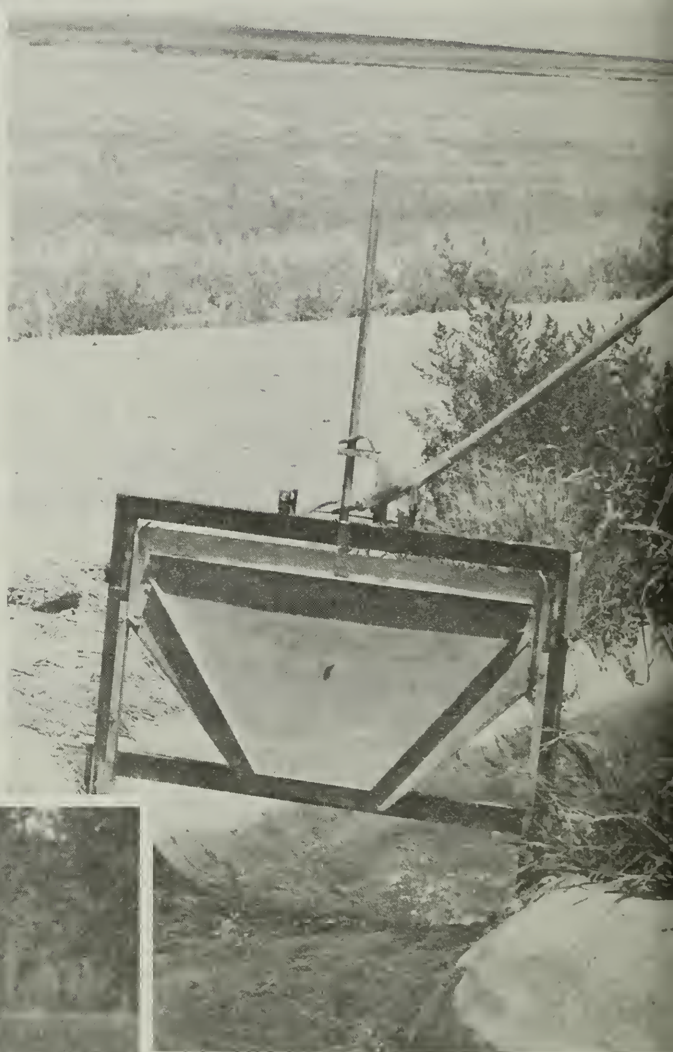
The following is a list of canal systems analyzed;
(See plate "Irrigation Systems Inventoried" for location)

Location Code	Canal Name	Location Code	Canal Name
10-1	Chilcott	14-7	*Lake Henry
10-2	*Fountain Mutual	13-1	*Resser Locke
10-3	Lock	12-1	Garden Park
67-1	*Buffalo	12-2	*Canon City Hydraulic
67-2	*Amity	12-3	*Grandview
67-3	*Fort Bent	12-4	Fruitland
67-4	*Hyde	12-5	*Harrington
67-5	*Manvil	12-6	*Cascade
67-6	*Lamar	12-7	Pump
17-1	*Otero	12-8	*Canon City Oil Creek
17-2	*Fort Lyon	12-9	South Canon
17-3	*Holbrook	12-10	Fremont
17-4	*Rocky Ford	12-12	Canon Heights
17-5	*Catlin	12-13	*Lester Atterberry
15-1	Bryson	12-14	Union Ditch and Water Co.
16-3	Holita	12-15	*Beaver Park
16-7	*Palmer	12-16	*Pleasant Valley
14-1	*Bessemer	12-17	Baker Potter
14-2	*Oxford Farmers	18-7	*Lucero
14-3	*West Pueblo Enlargement	19-10	Hoehne
14-4	*Collier	19-15	*Highland
14-5	Rocky Ford Highline	11-17	*Bowen
14-6	*Colorado	11-22	*North Fork

(Note - * Marks systems with feasible alternatives. The number code (10-1) is for location purposes on map showing systems inventoried).

Concrete Canal Lining
Reduces Seepage Losses

Water Control Structures
Help Manage Irrigation Water



Efficient Water
Application Contributes
to Irrigation Water
Management

Table II-1 Irrigation System Practices (32 Selected Canal System)
Arkansas River Basin, Colorado

Practice	Total Needs	Plan 1/ A	Plan 1/ B
Conveyance Systems			
Cleaning (mi)	18	0	0
Lining (mi)	179.05	0	17.45
Pipeline (mi)	55.9	0	0.25
Diversion str. (no)	16	16	16
Control str. (no)	873	203	260
On-Farm System			
Lining (mi)	1,174	0	111.6
Pipeline (mi)	1,473	0	174.3
Control str. (no)	6,891	1,700	1,819
Land Leveling (ac)	96,590	25,895	28,165
Drainage (ac)	30,825	0	2,475
Irr. Water Management 2/ (ac)	313,087	75,175	101,308
Phreatophyte Eradication	645	0	170

1/ Table values are a summary of canal system practices. Plan A tends to maximize net income and plan B includes all economically feasible measures.

2/ This is a non-structural practice involving improvements in:
- Irrigation scheduling
- Time of irrigation set
- Optimum stream size
- Tailwater management
- Minor irrigation method change
- Maintenance of ditches and canals

Fencing to Prevent
Overuse of Rangeland

Re-seeding of Potential
Erosion Area

Stock Ponds help
Distribute Livestock

of conservation practices that are needed to solve problems on a specific operating unit. The selected conservation practices for the levels of treatment are as follows: Level 1 - no accelerated action; Level 2 - proper grazing use, fencing for management, deferred grazing, planned grazing system, pasture and range seeding, and stockwater development; Level 3 - critical area planting, fencing for exclusion, livestock exclusion, grade stabilization, diversion, terracing, erosion control dam, and sediment basin; Level 4 - combinations of practices from levels 2 and 3. The accelerated land treatment discussed in this report would be applied to the critical erosion areas only.

M&I Water

This phase of the study included identifying those rural communities of population less than 5,000 that have significant water supply problems. Table I-3 in Chapter I is a summary of M&I system needs in regards to water quantity and quality (see plate - M&I Communities - Since this study was initiated the following communities have resolved their problems; Cheraw, Crowley, Limon, Starkville, Swink).

Alternatives were not identified for this section of the study, however, a number of important factors that should be considered in community water system planning were identified. One of these is the amount of water needed to meet the estimated future requirements of the city, since the quantity to be developed will have a bearing on which one of several sources should be used and what the cost of the water will be. The estimate of future water supply requirements may be based upon an analysis of the community's prospects for future growth or upon a decision of community leaders to provide a given amount of domestic and industrial water as a stimulus for expansion of its economy. The community would also consider what alternative sources of supply are available through expansion or improvement of its present source or development of a new source of supply. In some areas groundwater may be developed and, for small to moderate-sized communities, this source is frequently most economical. In addition to groundwater supplies, consideration would be given to the cost of building a single-purpose water supply impoundment on one of the streams in the area. For a given stream there may be the question of whether it is more economical to provide the water through the development of a single-purpose reservoir or through provision of water supply storage in a multiple-purpose structure. Quality of water is another factor to consider in selecting a source of water supply, since natural or artificial pollution may limit the desirability of either ground or surface supplies. In some cases, adoption of appropriate pollution-abatement measures would, in effect, provide new sources of water supply or permit continued use of existing sources.

Increased Water Supply

A water yield analysis was considered important because of severe water shortage problems in the basin. Certain research watersheds have shown an increase in runoff as a result of blowing snow management and vegetation management. Timber cutting in blocks of certain dimensions can cause significant increases in water yield. Under the right circumstances, snowfences can be used to drift snow and trap moisture that would otherwise be lost.

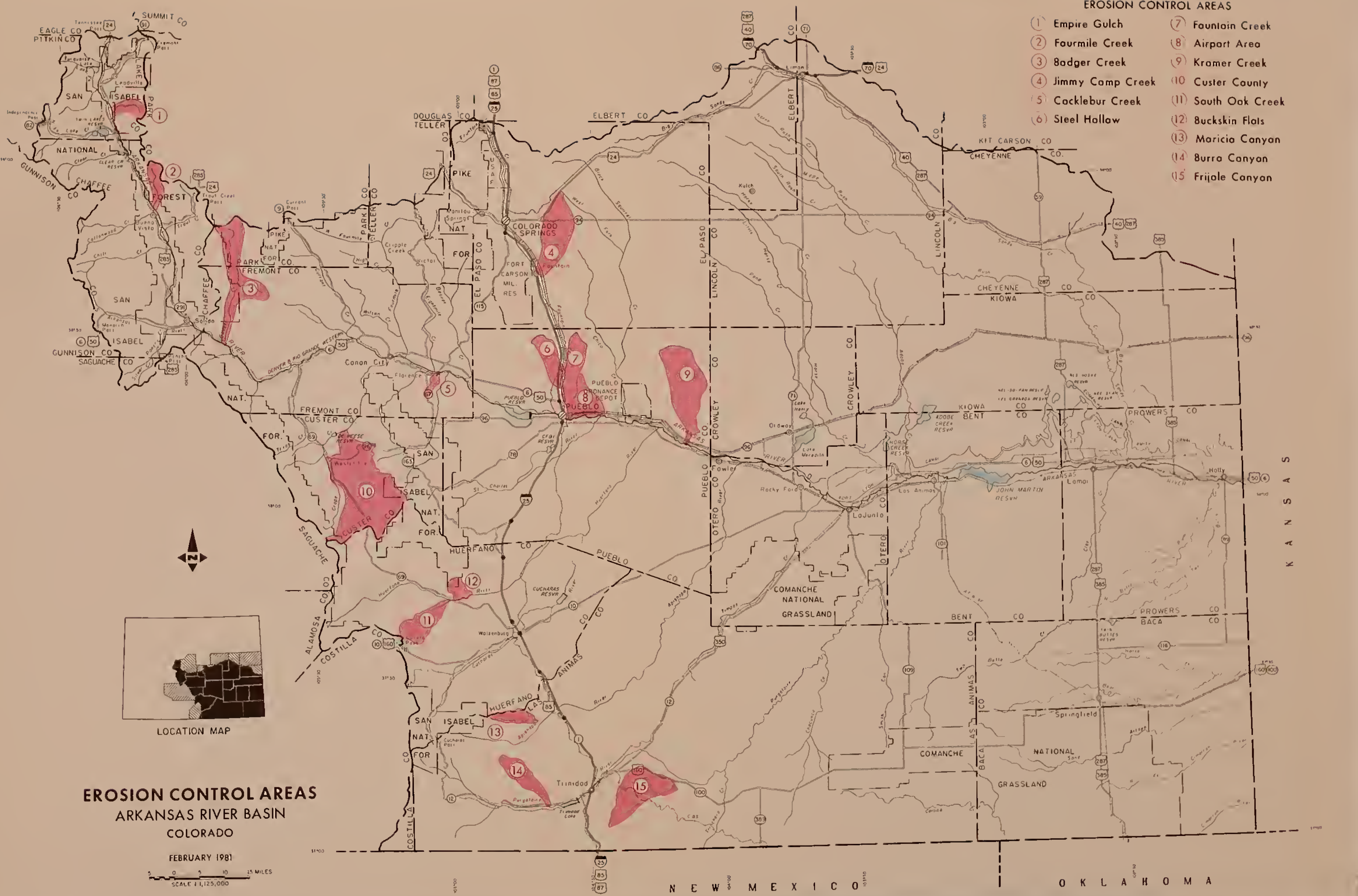
Snow Management
Affects Water Yield

Table II-7 shows the potential water yield increase available under three levels of development. These figures are not to be construed in any way as implementable alternatives. Much of the land base is in the Pike-San Isabel National Forest. A land and resource management plan for the National Forest is currently being prepared under guidance of the Forest and Rangeland Renewable Resources Planning Act (RPA), as amended by the National Forest Management Act of 1976.

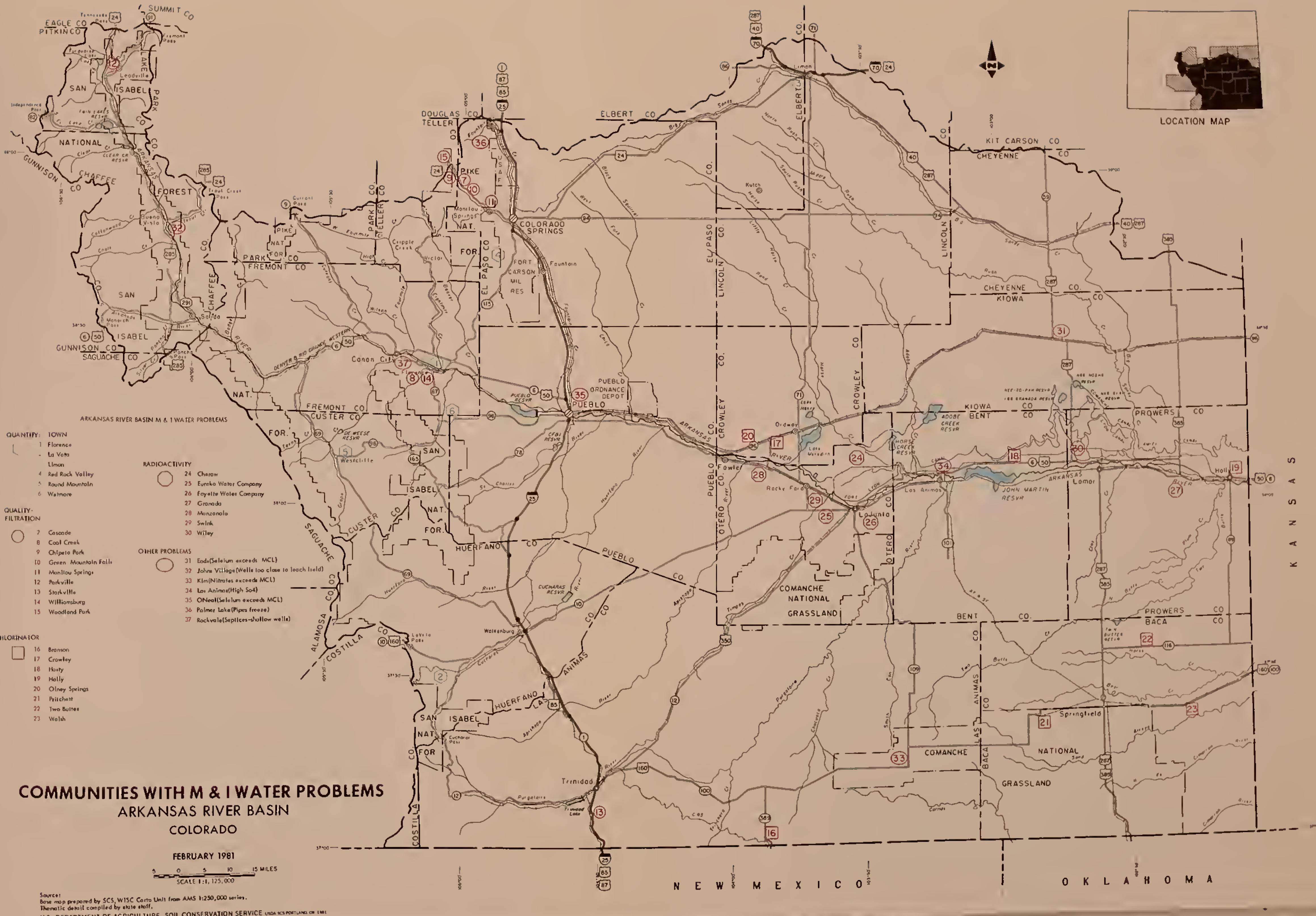
The Pike-San Isabel National Forest planning effort has not yet progressed to the point that water yield augmentation alternatives can be identified. However, the significance of increased water yield has been identified both as a regional and as a local concern. The Forest Plan, due in 1983, will include recommendations and a proposed plan of action for addressing the water yield concern.

The State Forest Resources Plan, in conjunction with the National Forest Plan, becomes support planning for the Resources Planning Act. Congressional support for the RPA Program and subsequent budget offers the primary vehicle for implementation.

With regard to Table II-7, "Water Yield Increase Potential," the objective here is to simply analyze the potential for water yield augmentation in light of the fact that the basin has a major water shortage problem in agriculture.



Source:
Base map prepared by SCS, WISC Carto Unit from AMS 1:250,000 series.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE



COMMUNITIES WITH M & I WATER PROBLEMS
ARKANSAS RIVER BASIN
COLORADO

FEBRUARY 1981

SCALE 1:1,125,000

Source:
Base map prepared by SCS, WISC Carto Unit from AMS 1:250,000 series.
Thematic detail compiled by state staff.

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

COMPARISONS AND ENVIRONMENTAL ASSESSMENTS OF ALTERNATIVES

Irrigation Water Management

Table II-2 and II-3 show comparisons of certain economic, land, and water related characteristics for the present level of activity vs conditions for 2 plans previously discussed. More specific tables showing individual system information are included in the appendix.

Crop consumptive use, which translates into increased yields, would be increased by 15 percent above present conditions for plan A, and 28 percent for plan B.

The economic analysis showed that greater net returns could be achieved, in this short water situation, by reducing the number of acres presently irrigated, and changing cropping patterns to emphasize high value crops.

Highlights of significant environmental effects are as follows:

Environmental Impact

Maximum Net Income (plan A) - No significant adverse environmental impact is anticipated. Approximately 26,000 acres of land leveling will reduce erosion and sedimentation within the irrigation systems and improve the irrigation water management.

The quality of water of surface return flows and groundwater recharge would be improved by reducing the salt pick-up by approximately 50,000 tons per year (4%).

Maximum level of development (plan B) - Approximately 18 miles of palustrine (along irrigation canal) habitat and the adjoining upland habitat will be altered or destroyed by canal lining and pipelines on the conveyance systems. Approximately 286 miles of palustrine (along irrigation farm ditches) habitat and adjoining upland habitat will be altered or destroyed by pipelines and ditch lining of the on farm systems. A total of 300 miles of canal and ditch lining and pipelines proposed by this alternative represents approximately 11% of the total needs of the systems studied.

Approximately 170 acres of wetlands and phreatophytes will be lost as a part of system improvements.

Quality of water of surface return flows and groundwater recharge would be improved by reducing the salt pick-up by approximately 90,000 tons per year (8%). No prime farm lands would be impacted.

Table II-2 Irrigation System Benefit-Cost and Other Characteristics
Arkansas River Basin, Colorado

	Unit	Plan 1/	
		A	B
Acres Served	AC	236,593	241,608
Benefit-Cost Factors 3/			
Installation Cost	$	39,600,185	70,325,357
Avg Annual Cost	$	4,131,805	7,230,096
Avg Annual Benefit	$	6,358,206	7,481,691
Characteristics of Alternatives			
Avg Annual Net Benefit	$	2,226,401	251,595
Irrigation System Eff. 2/	%	54/34	57/36
Salinity Reduction	Tons	49,697	89,566
Prime Lands with Full Water	AC	43,769	55,907

1/ Table values are a summary of canal system data. Plan A tends to maximize net income and plan B includes all economically feasible measures.
2/ Conveyance Efficiency and On-Farm Efficiency (Conveyance/On-Farm)
3/ Costs were amortized at 7 1/8 % for 25 years. 1980 prices were used for Costs and Benefits. Costs include OM&R.

Table II-3 -- Irrigation System Characteristics Impacted By Alternatives Treatments
Arkansas River Basin, Colorado

Characteristics Impacted	Unit	Present Level	Plan 1/ A	Plan 1/ B
Acres 2/				
Present				
Adj. Ac. to optimize net return	Ac	313,087		
Water supplies are insufficient 3/	Ac	231,110	236,593	241,608
Full water supply				
Short water supply	Ac	46,762	51,256	63,771
CIR shortage	Ac	266,325	185,337	177,838
Poor irr. water mgt.	AF	490,278	330,736	316,512
Canal seepage				
On-farm losses	AF	276,531	259,089	240,252
System irr. eff. (convey/on-farm)	AF	268,986	268,653	271,778
Poor quality irr. water 4/	%	51/31	54/34	57/36
Salt in Surface Return Flows				
Salt in Ground Water Recharge	Tons	101,951	98,579	97,886
More Beneficial Water Use	Tons	1,145,984	1,101,817	1,053,126
Crop Consumptive Use				
Phreatophyte-Wetland Evapo Transp	AF	121,523	139,334	155,046
Return flows	AF	92,981	92,981	92,013
Total surface return flow				
Net ground water recharge	AF	51,779	50,089	49,081
	AF	294,229	278,117	264,901

1/ Table values are a summary of canal system data. Plan A tends to maximize net income and plan B includes all economically feasible measures.
2/ Data for present condition based on 313,087 ac, under 32 canal systems.
3/ Based on 560,500 A.F. diverted, and 106,600 A.F. pumped. CIR = Consumptive Irrigated Requirement.
4/ Salt concentrations assumed identical for present level and both plans.

Short-term use versus long-term productivity

Both the Maximum Net Income plan and Maximum Development plan call for a reduction of irrigated acres by about 20 to 25 percent. Economic and other impacts related to the possible use of these acres for other purposes were not evaluated. Both plans propose to improve the irrigation systems thereby stabilizing the economies of the agricultural base and improve productivity of the areas for future generations.

Commitment of Resources

The labor, capital resources and energy required to carry out the plans would be irretrievably committed.

The land committed to the alternative plans is existing crop and pasture land. The crop distribution may change to some extent with more emphasis given to high value crops. Both plans call for a reduction of acres irrigated from the present level. This would leave a number of acres available for other uses. The water supply would remain committed to the same extent as in the past.

Relationship of Alternatives to Land Use Policies

The U.S. Department of Agriculture has an established Land Use Policy with regards to the prime, unique and important lands of the nation. This policy, contained in the Secretary's Memorandum No. 1827, requires that any project planned by USDA programs will consider alternatives that would minimize the loss of land areas that are classified as prime, unique or important. The plans proposed herein to improve irrigation systems would not create a loss of any land area classified as prime, unique or important.

Executive order 11,990 deals with minimizing the destruction, loss or degradation of wetlands, and preserving and enhancing natural and beneficial values of wetlands. Plan B would remove about 170 acres of wetlands and phreatophyte acres.

Water Erosion Control

See Table II-5a and II-5b for the effects of water erosion control implementation and Table II-6 for comparisons of the levels of treatment to reduce erosion. The total area studied is 420,707 acres, of which 12 areas totaling 407,319 acres are on private land and 3 areas totaling 13,388 acres are on National Forest land.

Individual conservation practices were selected as the optimum for solution of the water erosion problems identified. This accelerated land treatment considered in the WIR's and in this report would be applied to the critical water erosion areas only, and no attempt was made to develop comprehensive resource plans for the areas. Highlights of significant environmental effects are as follows:

Table II-4 Effects of Irrigation Project Implementation
Arkansas River Basin Colorado

Component	Unit	Present Level	Plan 1/ A	Plan 1/ B
National Economic Development (NED)				
Increased Value of Goods and Services 2/				
(a) Annual Crop Benefits	$		4,924,857	5,905,560
(b) Other Benefits	$		1,433,349	1,576,131
(c) Annual Project Benefits	$		6,358,206	7,481,691
(d) Annual Net Benefits	$		2,226,401	251,595
Irrigation and Land-Structure Treatment costs 2/				
(a) Annual Installation	$		3,437,507	6,102,836
(b) Annual OM&R	$		694,298	1,127,260
(c) Total Annual	$		4,131,805	7,230,096
Crop Distribution				
(a) Alfalfa	Ac	140,518	116,039	116,108
(b) Corn	Ac	56,096	38,493	43,039
(c) Grass Hay (other)	Ac	7,665	7,986	7,986
(d) Grass Pasture	Ac	1,054	815	815
(e) Orchards	Ac	590	599	599
(f) Spring Grain	Ac	14,486	11,574	11,974
(g) Sorghum	Ac	72,973	46,367	46,367
(h) Vegetables	Ac	17,713	12,353	12,353
(i) Winter Wheat	Ac	1,992	2,367	2,367
Total	Ac	313,087	236,593	241,608
Environmental Quality (EQ)				
Water and Land Quality				
(a) Salt in Return Flows and Ground Water Recharge	Ton	1,182,487	1,132,803	1,092,921
(b) Prime Agr. Lands with Full Water Supply	Ac	41,394	43,683	55,907
Biological Measures				
(a) Wetland	Ac	15,332	15,332	15,162
(b) Phreatophytes	Ac	1,250	1,250	1,250
(c) Cottonwoods	Ac	667	667	667
Visual Characteristics				
(a) Land Irrigated	Ac	313,087	236,590	241,605

Table II-4 (con't)

Component	Units	Present Level Total Yield	Present Level Yield Per Ac	Plan 1/ A	Plan 1/ B
Change in Crop Yields					
(a) Alfalfa	Ton	244,575	1.74	229,714	1.97
(b) Corn	Ton	960,230	17.11	660,162	17.15
(c) Grass Hay (other)	Ton	13,581	1.77	15,121	1.89
(d) Grass Pasture	AUM	2,929	2.77	2,480	3.04
(e) Orchards	BU	236,000	400.0	239,600	400.0
(f) Spring Grain	BU	344,733	23.79	412,935	35.67
(g) Sorghum	CWT	1,880,414	25.76	1,608,349	34.68
(h) Vegetables	Ton	163,820	10.0	123,530	10.0
(i) Winter Wheat	BU	119,837	36.06	88,886	37.55

Other Social Effect (OSE)

Job Creation or Loss Project Construction Total Unskilled and Semiskilled Labor	man/yr	0	19.57	34.76

1/ Table values are a summary of canal system data. Plan A tends to maximize net income and plan B includes all economically feasible measures.

2/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits.

Environmental Impact

Level 1 - No adverse effects are anticipated. Sediment yield would be reduced by 88,200 tons per year and the annual critically eroding areas would be reduced by 9,700 acres. Aesthetic quality of the landscape and the wildlife habitat would not be significantly changed. Wetland areas would be increased by 46 acres.

Level 2 - No adverse effects are anticipated. Sediment yield would be reduced by 159,400 tons per year and the annual critically eroding areas would be reduced by 20,500 acres. Aesthetic quality of the landscape would be improved but the quality of wildlife habitat would not significantly change. Wetland areas would be increased by 34 acres.

Level 3 - No adverse effects are anticipated. Sediment yield would be reduced by 526,000 tons per year and the annual critically eroding areas reduced by 16,500 acres. Aesthetic quality of the landscape would be improved. Wetland areas would be increased by 377 acres, however the quality of the wildlife habitat would not be changed.

Level 4 - No adverse effects are anticipated. Sediment yield would be reduced by 755,500 tons per year and the annual critically eroding areas reduced by 57,000 acres. Aesthetic quality of the landscape is significantly improved. Wetland areas would be increased by 396 acres, however the quality of the wildlife habitat would not be changed.

Short term uses and enhancement of long term productivity

None of the levels of treatment would change the present use of the areas. All levels would stabilize the eroding areas and protect the land resource base for future generations. Long-term agricultural productivity of the areas would be improved by all the levels of treatment.

Commitment of Resources

The land that would be committed to the levels of treatment is primarily rangeland. The use of the land would not change upon implementation of the treatment.

Land, labor, capital resources, and energy used to implement the levels of treatment would be irretrievably committed.

The current annual loss of soil and land resources to erosion would be reduced by any of the levels of treatment.

The following chart displays the estimated cost of reducing sediment:

	Average Annual Cost ($)	Annual Cost of Sediment Reduced ($ Per Ton)
Level 1	61,100	0.70
Level 2	268,600	1.70
Level 3	2,213,800	4.30
Level 4	2,097,200	2.80

Relationship of Alternatives to Land Use Policies

See the section on irrigation water management of this chapter for the discussion on USDA policy on prime, unique and important lands.

The levels of treatment proposed in the report to reduce critical water erosion would not effect any prime, unique or important farm, ranch, timber or wetlands.

M&I Water

Alternatives were not developed.

Increased Water Supply

Patch clear cut treatments are designed to maximize snow accumulation in 3-5 acre patchs. In this evaluation, approximately 30 percent of the commercially available pole size timber and sawtimber would be cut during the treatment. As the stands regenerate, a second treatment could occur 30 or 40 years from now.

Conversion of brushlands to grass increases water yield by reducing the evapotranspiration. Site conversion to grass does retain enough brush for wildlife habitat purposes and would be patterned to make the most of the remaining brush for blowing snow management.

Blowing snow management using snow fences in conjunction with existing vegetation was also evaluated. Table II-7 "Water Yield Increase Potential" indicates the potentials for the separate treatments. An upper limit of no more than 30% of the watershed will be in a water yield treatment phase at any one time. This upper limit is necessary to maintain stream channel stability. Future field work and evaluation would be necessary for the implementation phase.

Table II-5a Effects of Water Erosion Control Implementation On Private Lands (Total of 12 Areas - 407,319 Acres) Arkansas River Basin, Colorado

Component	Unit	July 1980 Conditions	(Conditions at the end of 25 years) Level #1	Level #2	Level #3	Level #4
National Economic Development (NED)						
Installation Cost	$	0	441,900	1,907,900	15,420,900	14,802.600
O&M Cost (annual)	$	0	12,000	52,700	527,400	444,200
Technical Asst. (25%)	$	0	111,400	477,000	3,488,000	3,700,500
Job-Days	No.	0	691	2,980	21,797	23,468
Environmental Quality (EQ)						
Biological Measures						
Upland Habitat	Index	Med	Med	Med	Med	Med
Riparian Habitat	Index	High	High	High	High	High
Wetlands	Ac.	7,177	7,223	7,211	7,554	7,573
Phreatophytes	Ac.	925	925	925	925	925
Cottonwoods	Ac.	261	261	261	261	261
Sediment (gullies) Yield	Tns/Yr	867,700	790,900	730,700	367,200	174,300
Land Area Damage (Flood Plain)	Ac/Yr	0	0	0	0	0
Critical Erosion	Ac/Yr	63,600	53,900	44,000	48,200	7,800
(Sheet & Rill)	Tns/Yr	113,300	101,900	93,900	92,200	56,300
Land Voiding	Ac/Yr	46.8	42.7	39.4	19.3	9.6
Primelands	Ac.	140	140	140	140	140
Archaeologic & Historic	Sites	0	0	0	0	0
Aesthetic Quality	Index	0.50	0.51	0.53	0.59	0.65
Other Social Effect (OSE)						
Job Creation	No.	0	0	11.6	95.3	120.9
Canal Damage by Siltation	Mi.	0.57	0.57	0.48	0.28	0.14
Productivity (rangeland)	AUM's	49,900	55,900	68,900		88,600

Table II-5b Effects Of Water Erosion Control Implementation
On Public Lands Administered By The Forest Service (Total of 3 Areas - 13,388 Acres)
Arkansas River Basin, Colorado

Component	Unit	July 1980 Conditions	(Conditions at the end of 25 years) Level #1	Level #2	Level #3	Level #4
		National Economic Development (NED)				
Installation Cost	$	0	0	20,900	38,900	64,300
O&M Cost (annual)	$	0	0	1,600	3,200	6,100
Technical Asst. (25%)	$	0	0	5,100	11,000	15,800
Job-Days	No.	0	0	32	70	98
		Environmental Quality (EQ)				
Biological Measures						
Upland Habitat	Index	High	High	High	High	High
Riparian Habitat	Index	Med	Med	Med	Med	Med
Wetlands	Ac.	0	0	0	0	0
Phreatophytes	Ac.	0	0	0	0	0
Cottonwoods	Ac.	0	0	0	0	0
Sediment (gullies) Yield	Tns/Yr	100	100	100	100	100
Land Area Damage (Flood Plain)	Ac/Yr	0	0	0	0	0
Critical Erosion	Ac/Yr	1,300	1,300	400	200	100
(Sheet & Rill)	Tns/Yr	11,500	11,500	8,500	7,100	6,400
Land Voiding	Ac/Yr	0.1	0.1	0.1	0.1	0
Primelands	Ac.	0	0	0	0	0
Archaeologic & Historic	Sites	0	0	0	0	0
Aesthetic Quality	Index	0.50	0.50	0.52	0.55	0.56
		Other Social Effect (OSE)				
Job Creation	No.	0	0	0.1	0.3	0.4
Canal Damage by Siltation	Mi.	0	0	0	0	0

Table II-6 Levels of Land Treatment to Reduce Erosion 1/
Arkansas River Basin, Colorado

Project	Level #1				Level #2				Level #3				Level #4			
	Total Instal Cost $	Avg 4/ Ann. Cost $	Acres 2/ Critical Erosion Ac.	Tons of 3/ Sediment Reduced Tons	Total Instal Cost $	Avg 4/ Ann. Cost $	Acres 2/ Critical Erosion Ac.	Tons of 3/ Sediment Reduced Tons	Total Instal Cost $	Avg 4/ Ann. Cost $	Acres 2/ Critical Erosion Ac.	Tons of 3/ Sediment Reduced Tons	Total Instal Cost $	Avg 4/ Ann. Cost $	Acres 2/ Critical Erosion Ac.	Tons of 3/ Sediment Reduced Tons
Private Lands																
Cocklebur Creek	7,400	1,000	300	2,400	58,600	8,300	400	4,100	280,500	40,900	500	11,000	223,600	31,500	1,600	18,800
Jimmy Camp Creek	252,100	35,600	6,700	28,200	63,200	8,900	2,700	20,400	1,133,400	164,300	3,100	34,900	914,200	128,800	8,500	51,700
Fountain Creek	0	0	0	0	225,600	31,800	6,600	21,500	364,500	56,400	3,300	60,200	484,100	68,700	14,800	97,300
Airport Area	0	0	800	7,100	130,200	18,300	2,400	19,000	158,100	26,800	1,600	58,000	136,400	19,300	7,200	91,900
Steel Hollow Creek	15,900	2,300	700	7,500	102,400	14,500	5,600	12,800	283,900	44,000	2,800	36,700	256,100	36,100	12,700	60,100
Kramer Creek	24,800	3,000	700	2,400	177,800	21,500	1,100	4,100	399,300	60,300	1,500	10,300	495,400	66,600	6,700	18,300
Buckskin Flats	9,300	1,300	300	2,200	15,700	2,200	300	3,100	479,800	51,700	1,600	8,400	81,400	11,400	1,600	8,400
South Oak Creek	38,000	4,600	0	2,800	58,000	7,000	100	4,400	1,287,600	124,700	500	21,900	216,400	30,500	500	21,900
Burro Canyon	63,200	8,900	0	8,500	150,600	21,200	0	5,900	419,400	59,100	0	24,400	501,500	70,600	0	37,700
Frijole Creek	0	0	200	12,800	129,600	18,300	400	19,400	168,000	25,200	500	62,200	297,600	41,900	2,200	94,800
Mauricio Canyon	31,200	4,400	0	700	21,800	3,100	0	700	95,700	13,520	0	2,400	78,000	11,000	0	3,600
Custer County	0	0	0	13,600	774,400	109,100	0	41,000	10,350,700	1,538,200	0	191,200	11,117,900	1,566,400	0	245,900
Totals	$441,900	61,100	9,700	88,200	$1,907,900	264,200	19,600	156,400	$15,420,900	2,205,100	15,400	521,600	$14,802,600	2,082,800	55,800	750,400
National Forest Lands																
Empire Gulch	0	0	0	0	2,500	600	500	1,400	3,700	1,000	600	2,000	5,100	1,200	800	2,400
Little Union Creek	0	0	0	0	12,700	3,000	300	1,200	23,100	6,000	400	2,000	43,000	11,000	300	2,600
Four Mile Creek	0	0	0	0	5,700	800	100	400	12,100	1,700	100	400	16,200	2,200	100	100
Totals	0	0	0	0	20,900	4,400	900	3,000	38,900	8,700	1,100	4,400	64,300	14,400	1,200	5,100
Study Area Totals	$441,900	61,100	9,700	88,200	$1,928,800	268,600	20,500	159,400	$15,450,800	2,213,800	16,500	526,000	$14,866,900	2,097,200	57,000	755,500

1/ All figures rounded to the nearest 100 units.
2/ Average annual critical sheet and rill erosion acres reduced.
3/ Annual reduction of sediment produced by sheet, rill, gully and streambank erosion.
4/ Includes OM&R. Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits.

Environmental Impacts of Alternatives

The purpose of the vegetative treatments is to reduce the on-site consumption of water and release it to the stream. The sensitivity of impact increases with the magnitude of treatment.

Patch clear cutting does not require more total road system than conventional forest management. But it does require more of the road to be built early in the development phase. Roads are in themselves major environmental impacts.

Patch clear cutting changes the local aesthetics. It is estimated that general aesthetics will be reduced by development of the water yield potential of the timber stands. However, patch clear cutting could benefit wildlife by creating more edge effect.

Brush land conversion to grass is a controversial treatment. The aesthetics of site conversion from chaining out low profile trees is a major point of contention. Unless the benefits to grazing and to water yield clearly outweigh the costs, and unless a drastic change in local environment occurs, implementation is difficult to justify. However, conversion under the right circumstances or where it can be accomplished by less drastic means, such as firewood cutting, should provide better wildlife habitat, diversity, and improved grazing values.

Snow fences can have minimal effect on the environment. Treatments of this kind would favor the use of existing forest resources rather than the introduction of materials not natural to the forest environment. Where practical, snow fences would be built as "worm fences" or board fences rather than galvanized metal or wire and slat fences. This would minimize the adverse effects on aesthetics.

Extra water made available to the river system contributes to instream flows and to some extent, groundwater recharge. Although no attempt was made to value the instream flow for fisheries, wildlife, or recreation the additional water in the system is overall beneficial.

Short Term vs Long Term

The patch clear cut treatment effects last upwards of 40 years; brushland conversion, 20 years; and snowfence, 50 years. There is no basic reason to suggest that short term gains are obtained at long term expense. The vegetative treatments are not new and they are well enough monitored so that the risks are known. Soil productivity will not be reduced.

Blowing snow management is somewhat new as a water yield augmentation tool. However, careful research has established the opportunities and design criteria.

Commitment of Resources

For the vegtative treatments, the modifications made to the local ecosystems will eventually return to its present condition. Investments and personnel time would be committed to doing the job.

It is anticipated that treatment funds obtained by the Forest Service would be used to carry out the implementation phase. However, it would be equally possible that the corresponding users groups would participate with labor to accomplish the objectives.

The treatment of forest land could result in wood products marketable as sawtimber or fuel wood.

Relationship of Alternatives to Land Use Policy

The patch clear cut alternative is more expensive than conventional forest harvest techniques and therefore has not had extensive use. However, the research and development of the technique is adequate. If the water values can support the more expensive treatment, then the existing land use policies would be completely supportive.

The conversion of brushland is far more controversial. Careful analysis and design of projects to ensure the protection of the resources and visual quality would be especially necessary. Once adequately developed however, implementation could go ahead.

The management of blowing snow for water yield increases is relatively new technology. Current land use policies would not prevent a carefully designed project from implementation.

The Rocky Mountain Region of the Forest Service makes commitments in its regional plan to help ensure an adequate supply of quality water. The Regional Forester has actively pursued a program for water yield augmentation from vegetation and blowing snow management techniques. Regional direction to the National Forests for use in their planning effort includes the need to evaluate water yield increase potential.

The high elevation water yield area of the Arkansas lies in large part in the Pike-San Isabel National Forest. The National Forest land plan is currently being planned using standards and guidelines developed in the regional plan. The plan is not yet complete.

The information dealing with how much water yield increase will be generated under the Pike-San Isabel National Forest's preferred alternative, is not available. The quantity will likely be much less than the values in Table II-7, largely because this study did not take into account the large number of constraints and public desires that the forest planning process must contend with.

Table II-7 Water Yield Increase Potential
Vegetative And Blowing Snow Management Treatments 1/

Arkansas River Basin, Colorado

	Units of Measure M=1000's	Patch Clear Cuts		Brushland Treatment	Snow Fence Construction	
		Reach 11	Reach 12	Reach 11&12	Reach 11	Reach 12
National Economic Development (NED)						
Treatments						
Snowfence	Miles				339	71
Brushland site conversion	M Acres			54.5		
Timber harvest 3-5 acres patch cuts						
Sawtimber stands	M Acres	33	5.5			
Pole timber stands	M Acres		17.5			
Expected Life of Treatments	Years	40	40	20	50	50
Outputs						
Water Yield Increase						
Treatment year maximum	M Ac Ft	3.0	6.1	4.5	6.0	3.1
Total over treatment life	M Ac Ft	51.8	136.0	73.3	194.4	104.0
Sawtimber	MM BF	397	66	0	0	0
Roundwood	MM CF	0	42	0	0	0
Grazing	M AUM	14	10	14	0	0
Economics 2/						
Treatment Cost	M $	264	1,408	4,100	1,600	748
Treatment Benefits	M $	435	895	665	1,362	718
Average Annual Costs	M $	20	104	301	263	55
Average Annual Benefits	M $	32	66	49	100	53
Benefit/Cost Ratio	Ratio	1.6	0.6	0.2	0.4	1.0

Table II-7 (con't)

	Units of Measure M=1000's	Patch Clear Cuts Reach 11	Patch Clear Cuts Reach 12	Brushland Treatment Reach 11&12	Snow Fence Construction Reach 11	Snow Fence Construction Reach 12
		Environmental Quality (EQ)				
Erosion on-site						
Treatment maximum	M Ton/Yr	999	696	2	2	0.4
Total over treatment life	M Tons	2,432	1,692	20	20	4
Average over treatment life	M Ton/Yr	61	42	164	.4	.1
Average per acre over treatment	Ton/Ac/Yr	1.8	1.8	3	T	T
Wildlife Habitat Quality						
Big Game over treatment life	Rating	High	High	Med	Med	Med
Non Gamer over treatment life	Rating	High	High	Med	Med	Med
Archaeological & Historic	Sites	0	0	0	0	0
Aesthetic Quality Index	0-1	0.9	0.9	0.5	0.3	0.3
Instream flows - annual	M Ac Ft	5	10	7	10	5
Temporary Roads Added	Miles	206	144	83	339	71
Prime Forestland Lost	Acres	0	0	0	0	0
Critical Wildlife Areas Lost	Acres	0	0	0	0	0
		Other Social Effect (OSE)				
Jobs Created	Job Years	7	38	112	99	20

1/ These figures are essentially unconstrained by other land management or planning objectives. The amount of water yield from an implementable plan would likely be much less.

2/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits.

CHAPTER III - IMPLEMENTATION

INTRODUCTION

This chapter outlines the federal, state and local programs which may be used to implement various alternative treatment measures. Specific request for assistance must be made before any of the alternative measures can be implemented on private lands.

USDA PROGRAMS

Forest Service

Multiple Use - Sustained Yield Act

This Act provides for the management and development of the recreation resource on national forests. Forest Service recreation programs are coordinated with the private sector and other government agencies to avoid duplication of effort.

Forest resources on national forest lands are managed to conserve the land and its natural vegetation while providing feed for livestock and wildlife. Under the multiple use management concept, grazing lands are also required to be managed for their watershed, wildlife and recreation values. Programs for rehabilitating poor condition range lands to increase forage production are an important part of the Forest Service range programs.

The Act also makes provisions for timber management and includes the various management practices designed to improve the vigor, stocking, composition, productivity and quality of forest stands.

Small Watershed Program - Public Law 83-566

In cooperation with other USDA Agencies, this program involves planning and implementing measures for the protection, conservation and improvement of land and water resources. Through national forest management and cooperative programs with state and local governments, and private landowners, the Forest Service participates in the protection, management and use of forest and associated watershed lands. Through Public Law 566 assistance is provided for gully stabilization, erosion control, rehabilitation of abandoned roads and trails, restoration of mined areas, and full development of multiple use on state and private lands.

Cooperative Forestry Assistance Act of 1978 - Public Law 95-313

Under this program the Forest Service is authorized to work through and in cooperation with State Foresters and equivalent State officials in implementing Federal programs affecting nonfederal forest land by providing assistance in (1) the advancement of forest resource management; (2) the encouragement of the production of timber; (3) the prevention and control of insects and diseases affecting trees and forests; (4) the prevention and

control of rural fires; (5) the efficient utilization of wood and wood residues, including the recycling of wood fiber; (6) the planning and conduct of urban forestry programs; (7) the improvement and maintenance of fish and wildlife habitat; and (8) the enhancement of the soil and water resources.

This program complements the policies and directions set forth in the Forest and Rangeland Renewable Resource Planning Act of 1974.

Soil Conservation Service

Assistance to Conservation Districts - Public Law 46

Under the authorities of this program, the Soil Conservation Service through local conservation districts assists both individuals and groups in the planning and application of needed soil and water conservation on private lands. This Act can provide technical assistance to landowners for conserving land and water resources in the Basin in the national interest.

Small Watershed Program - Public Law 83-566

Under the authorities of this program, USDA agencies provide assistance to sponsoring local organizations in planning and carrying out a program for the development, use and conservation of the soil and water resources of a small watershed area. This includes treatment and protection of federally owned land within such watershed areas.

Great Plains Conservation Program

USDA assistance under this program is designed to accelerate the application of needed conservation practices to conserve land and water resources on private land. The program can provide cost-sharing to help offset the cost to landowners in the designated Great Plains counties. All the counties in the Basin, except for Lake County, are designated as Great Plains counties.

Resource Conservation and Development Program

The Resource Conservation and Development Program (RC&D), administered by the Soil Conservation Service, is designed to expand the economic opportunity for people in approved planning areas. Under the program, USDA agencies provide technical, cost-sharing and loan assistance to local sponsors by developing and carrying out action plans for conservation improvement, development and wise use of natural resources. All of the Sangre de Cristo and part of the East Central Colorado RC&D areas are located within the Arkansas River Basin.

Agricultural Stabilization and Conservation Service

Rural Clean Water Program

The Rural Clean Water Program (RCWP) provides long-term technical and financial assistance to owners and operators having control of rural land. The purpose of this assistance is to install and maintain best management practices to control agricultural nonpoint source pollution for improved water quality.

Agricultural Conservation Program (ACP)

The ACP administered by the Agricultural Stabilization and Conservation Service provides funds for cost-sharing with individual and groups of landowners and operators for the installation of conservation practices.

Forestry Incentive Program

The Forestry Incentives Program (FIP) provides long-term technical and financial assistance to forest land owners. It is a cost share program with the purpose of providing for road access, forest protection, and timber stand improvement.

Farmers Home Administration

Loan Programs

The Farmers Home Administration is authorized to make loans to various non-federal landholders for the implementation of various land and water development measures. Landholders eligible for these loans are public and quasi-public bodies, nonprofit corporations and private individuals or groups owning land. Loan assistance is available for the development of recreation areas, irrigation and flood prevention facilities, and forestry and land treatment measures. Loans from FmHA may be used to pay the local share of most watershed projects and RC&D measures.

Colorado Water Conservation Board

The broad statutory mandate of the Colorado Water Conservation Board is to secure the greatest utilization of the water of the state, to prevent floods, and to protect the rights of the state in interstate streams. In this context, the Board is the state's policymaking and water planning agency in all matters concerning intra- and interstate water development, conservation and management. Furthermore, it has the responsibility of coordinating its functions with other state agencies and with other units of government, both federal and local, and of representing the state in interstate forums.

The Colorado Water Conservation Board is responsible for carrying out programs in seven major areas:

Project planning and construction;
Flood control and floodplain management;
River basin (regional) planning;
Protection of interstate waters and compacts;
Instream flow appropriations;
Colorado River Basin salinity control;
Hydrologic investigations.

Colorado Division of Water Resources (Office of the State Engineer)

The Division is responsible for the administration of the water supply of the state. The state statutes mandate that this division shall ensure that the state waters are preserved for the use and benefit of the citizens and inhabitants of the state for its growth, property and general welfare.

The Division of Water Resources is responsible for carrying out the following activities:

a. Operations of the Information Service program. This involves the collection, storage, and dissemination of water rights data and results of technical investigations and provides information to the general public.

b. Statewide regulation, analysis and coordination of groundwater use and supply in the state.

c. Evaluation of Colorado's surface water. This includes:

   (1) Evaluation and approval of plans for new dams and inspection of existing dams to maintain adequate safety standards.

   (2) Coordination of the actual measurement of surface water supplies.

(3) Evaluation and approval of requests for surface water supplies by subdivisions, industries, etc.

(4) Collection, storage, and evaluation of data on the amount of water available in the state.

(5) Provides geo-technical support within the Division and to other state agencies.

Colorado Geological Survey

The Survey is engaged in continuous programs in four major activities including:

a. Inventory and evaluate the mineral fuel resources (coal, methane, oil, gas, and oil shale) in the state and provide advice to state and local officials on matters relating to these resources.

b. Inventory, map, evaluate and promote the development of the state's mineral resources other than mineral fuels.

c. Study the availability of groundwater and geothermal resources.

d. Conduct project reviews on land use, subdivision proposals, and assist local governments in the identification and mitigation of geologic hazard areas.

Colorado Division of Parks and Outdoor Recreation

This Division is involved in continuous activities to protect, preserve, enhance and manage the natural, scenic, scientific and outdoor recreation areas for the use, benefit and enjoyment of the people. Specifically, the Division is responsible for:

a. Providing a comprehensive outdoor recreation program of planning, acquisition, and development of park areas.

b. Operate and manage existing parks and recreation areas.

c. Administer the Federal Land and Water Conservation Fund.

Two significant recreation areas in the Arkansas River Basin (Pueblo Reservoir and Mueller Ranch) are administered by the Division.

Colorado Division of Wildlife

This Division is responsible for the protection, preservation, enhancement and management of wildlife and their environment. Three major programs are implemented, on a continuous basis, to accomplish these objectives:

a. Maintenance of wildlife population numbers and providing hunting opportunities.

b. Same as (a) for fishing.

c. Administers the Non-Game Wildlife Program.

Specific programs underway in the Arkansas River Basin include:

a. Research on annual production and distribution of sport fish in river segments.

b. Operation of three fish hatcheries.

c. Lake habitat improvement - Great Plains Reservoirs.

d. Fisheries inventory and development - Pueblo and John Martin Reservoirs.

e. Evaluation of sport fisheries potential in fluctuating plains streams.

f. Big Horn Sheep and Mountain Goat investigations - Collegiate Peaks Herd.

g. Improvement of wildlife habitat on public lands.

h. Stream improvement on private lands.

i. Administration of nearly 20 wildlife management areas.

Colorado Water Quality Control Commission

The Commission is responsible for the development and maintenance of a comprehensive and effective program for the prevention, control, and abatement of water pollution for water quality protection. In connection with this function, the Commission shall classify the waters of the state, promulgate water quality standards, control regulations, and waste discharge permit regulations, enter into contracts with municipalities and individuals with respect to the location, design, construction, financing, and operation of sewage treatment plants. Administration of these programs is accomplished by the Division of Water Quality Control.

OTHER PROGRAMS - FEDERAL AGENCIES

U.S. Bureau of Reclamation

Project Skywater

This project is aimed at the study of precipitation management in the Colorado River Basin. Spillover effects from increased snow packs on mountain ranges separating the Colorado River Basin from the Arkansas could run as high as 40,000 extra acre feet. The 40,000 acre foot estimate comes from the research prospectus and reflects an assumption of full scale precipitation management operations in the Colorado River Basin.

Currently, the propectus identifies the next 8 years as a research and validation phase. There would not be any spillover effects into the Arkansas from the research phase. Following the research phase (eight years), the desirability of a full scale precipitation management operation would be opened for decision.

Fryingpan-Arkansas Project

This project, under construction by the Bureau of Reclamation, is a multiple-purpose project to develop the optimum use of water and related resources of the Upper Arkansas River Basin. The project involves diversion of water from the Colorado River Basin to the Arkansas River Basin to be stored and regulated for beneficial use in Colorado.

The project was authorized by Public Law 87-500 in 1962 and construction was initiated in 1964. At the end of the fiscal year (September 30, 1981) construction was completed on Ruedi Dam, Pueblo Dam, Sugarloaf Dam and Reservoir, Twin Lakes Enlargement, most of the North and South Side Collection System, Mt. Elbert Fore-Powerplant. Construction in Fiscal Year 1982 will be continued on Stage 2 of the Mt. Elbert Pumped Storage Powerplant, the municipal and industrial water system serving the Colorado Springs area and the recreational facilities at Pueblo Reservoir.

U.S. Corps of Engineers

Fountain Creek Flood Control Project

This project, planned by the Corps of Engineers, is located on Fountain Creek in Pueblo and would consist of a series of levees and channel improvements that would provide flood protection up to and including 85,000 cfs, a 200-year flood. In addition to channel improvements and levees, the proposed plan includes recreation facilities consisting of expansion of the existing trail system, a low flow channel, picnic facilities, playgrounds, wildlife habitat areas, and open space.

U.S. Geological Survey

The U.S. Geological Survey, in cooperation with the Colorado Division of Resources, conducts continuous studies in the Arkansas River Basin consisting of a Groundwater Data Network program and the maintenance of gaging stations.

APPENDIX A - RESOURCE BASE

Table of Contents

List of Tables

List of Figures & Plates

APPENDIX A - RESOURCE BASE

Much of this information is for the entire basin and therefore may be somewhat different than as shown in other sections of this report.

LOCATION

The Arkansas River Basin in Colorado can best be described as a great plains area bounded on the west by the eastern face of the Rocky Mountains. It covers approximately 28,415 square miles, about 27 percent of the State of Colorado. It is about 250 miles long (east to west) and averages about 150 miles wide (north to south). Kansas and New Mexico and Oklahoma are the eastern and southern boundaries, respectively.

The Arkansas River itself heads near Leadville, at over 10,000 feet above sea level. It drops rapidly until it emerges from the mountains near Pueblo, then meanders in an easterly direction until it reaches the Colorado-Kansas state line near Holly at the elevation of about 3,400 feet.

CLIMATE

Precipitation

The average annual precipitation (1941-70 base) in the basin varies from 16.8 inches at Leadville to 13.0 inches at Canon City, 11.9 inches at Pueblo, 12.5 inches at Rocky Ford, 12.9 inches at Las Animas and 15.3 inches at Lamar (see plate - precipitation). According to records of precipitation for Las Animas as kept at the Fort Lyon Canal Company office (more than 100 years of record), the lowest annual precipitation was 2.14 inches (1894), and the highest was 22.49 inches (1941). Over this period of record, July is the wet month with an average of 2.14 inches and January is the dry month with only 0.28 inches.

The Colorado State University published a report in 1975 dealing with precipitation in Colorado, "Analysis of Colorado Precipitation." Figure A-1 is a history of weighted precipitation from this reference. The main interest in this figure is that there is no significant trend in statewide precipitation for the 56 year period examined. Figure A-2 shows the weighted mean annual precipitation and monthly distribution for the lower portion of the basin.

Much of the precipitation at high elevations occurs as snow. Runoff from this snowfall is at a maximum in late spring and early summer. This runoff constitutes the dependable water supply for municipal, irrigation, industrial and other beneficial uses. A frequency analysis of snow pack water content representative of the basin is shown in Table A-1. Generally the April 1st snow water content of certain index stations is used in forecasting spring and summer streamflow.

Table A-1 -- Frequency Analysis of Snow Pack Water Content in the Arkansas Basin River Basin, Colorado

Frequency 1/ (Years)	Inches of Water February	March	April	May
1	1.29	4.44	5.75	3.65
10	3.56	6.47	8.19	6.37
20	4.86	7.46	9.37	7.78
50	7.38	9.54	11.81	10.78
80	9.24	11.82	14.44	13.97
90	9.81	13.05	15.86	15.61
99	10.35	16.00	19.21	19.12

1/ The frequency implies a return period, or the number of years between occurrences. (Source: Soil Conservation Service)

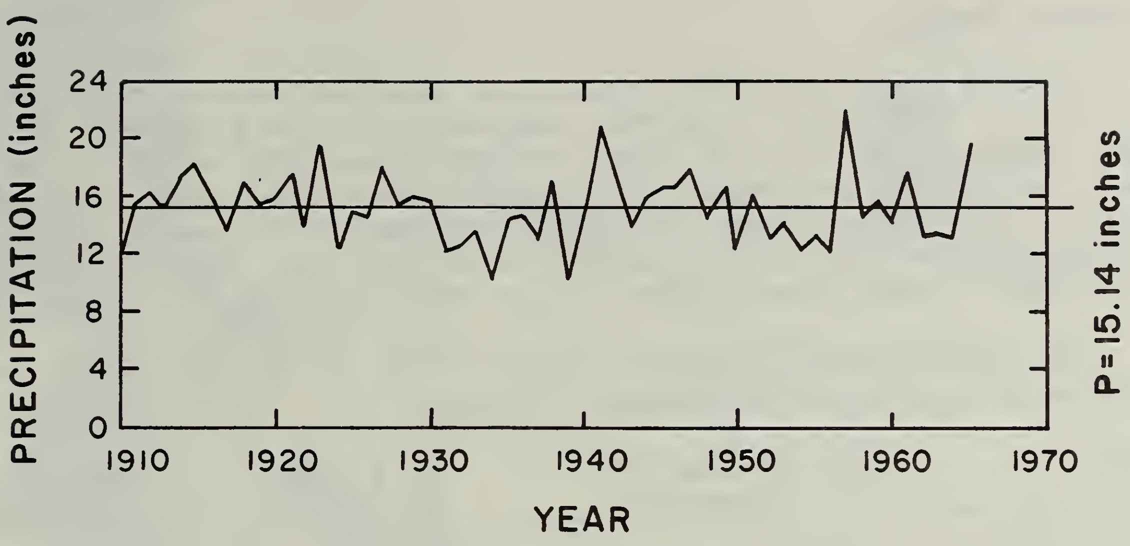


Figure A-1 Area weighted precipitation of Colorado 1910-1965.

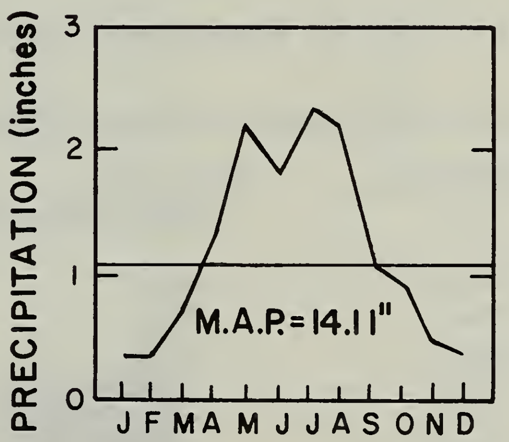


Figure A-2 Precipitation for Southeast Region of Colorado (Below 7500 Feet Elevation). M.A.P. is the mean annual precipitation.

Source: "Analysis of Colorado Precipitation"- Marie Kuo & Stephen K. Cox, Colorado State University.

Growing Season

Summers are cool in the mountainous areas and warm in the plains portion of the basin. A maximum temperature of 114°F has been recorded at Las Animas during July. A winter minimum temperature of -32°F has also been recorded at Las Animas which implies that large temperature variations occur. The average frost free season (between 32°F threshold) varies from 85 days at Leadville to 167 days at Canon City, 161 days at Las Animas and 162 days at Lamar. See figure A-3 for additional data.

The desired growing season for most crops can be determined from the following temperature thresholds criteria:

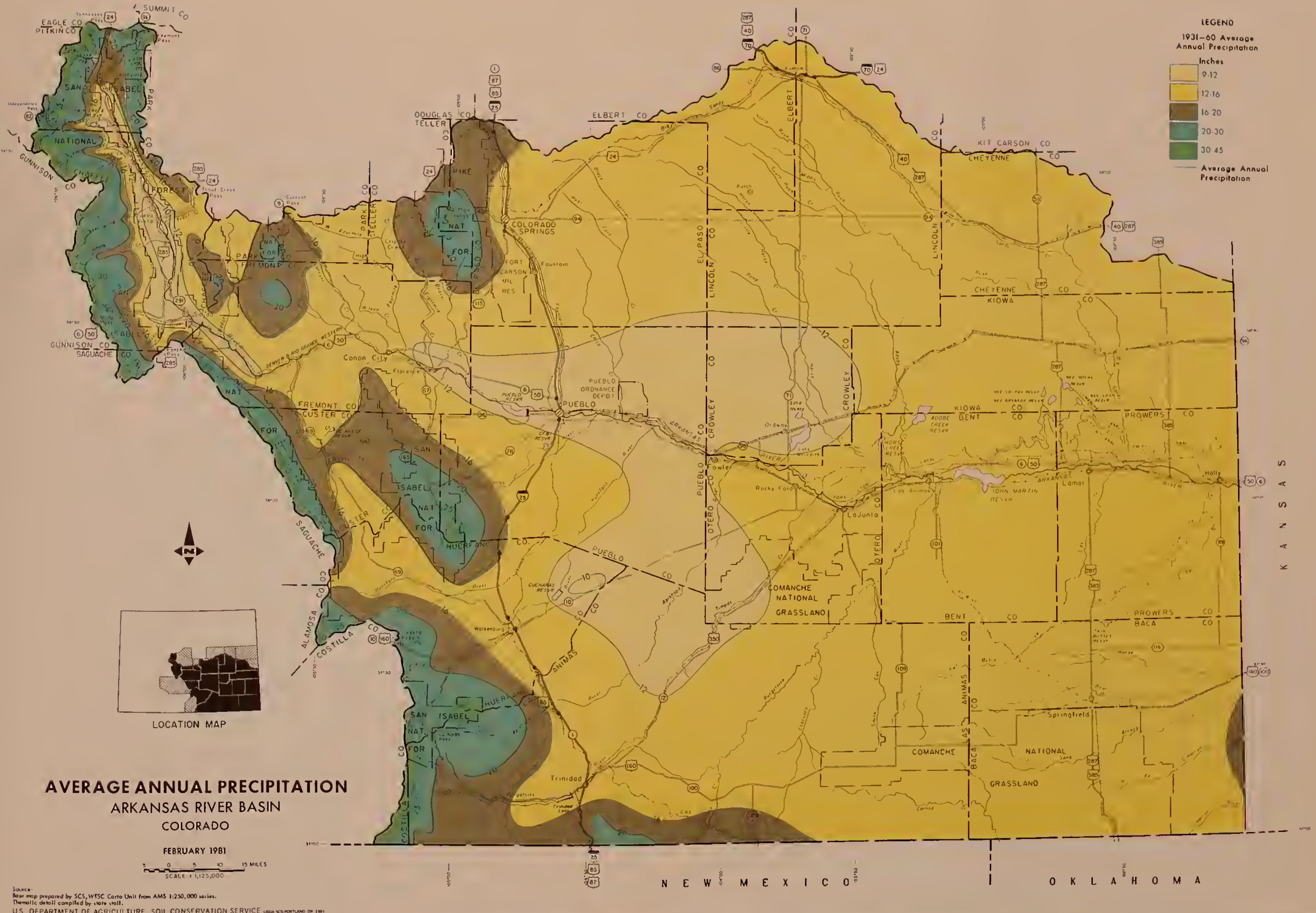
Crop	Spring Temp. Threshold	Fall Temp. Threshold	Desired Length of Season
Alfalfa	50° Mean	28° Frost	Variable
Grasses	45° Mean	45° Mean	Variable
Dry Beans	60° Mean	32° Frost	90-100 days
Corn (Grain)	55° Mean	32° Frost	140 days
Spr. Grain	45° Mean	32° Frost	130 days
Potatoes	60° Mean	32° Frost	130-150 days
Grain Sorghum	60° Mean	32° Frost	130 days

Source: Soil Conservation Service TR-21

Table A-2 gives mean temperature and frost dates for selected locations in the basin. With this information it can be determined for example that the growing season for grass pasture is from April 1 to October 31 at Lamar, and from June 1 to September 30 at Leadville.

Table A-2 - Mean Air Temperature and Frost Dates

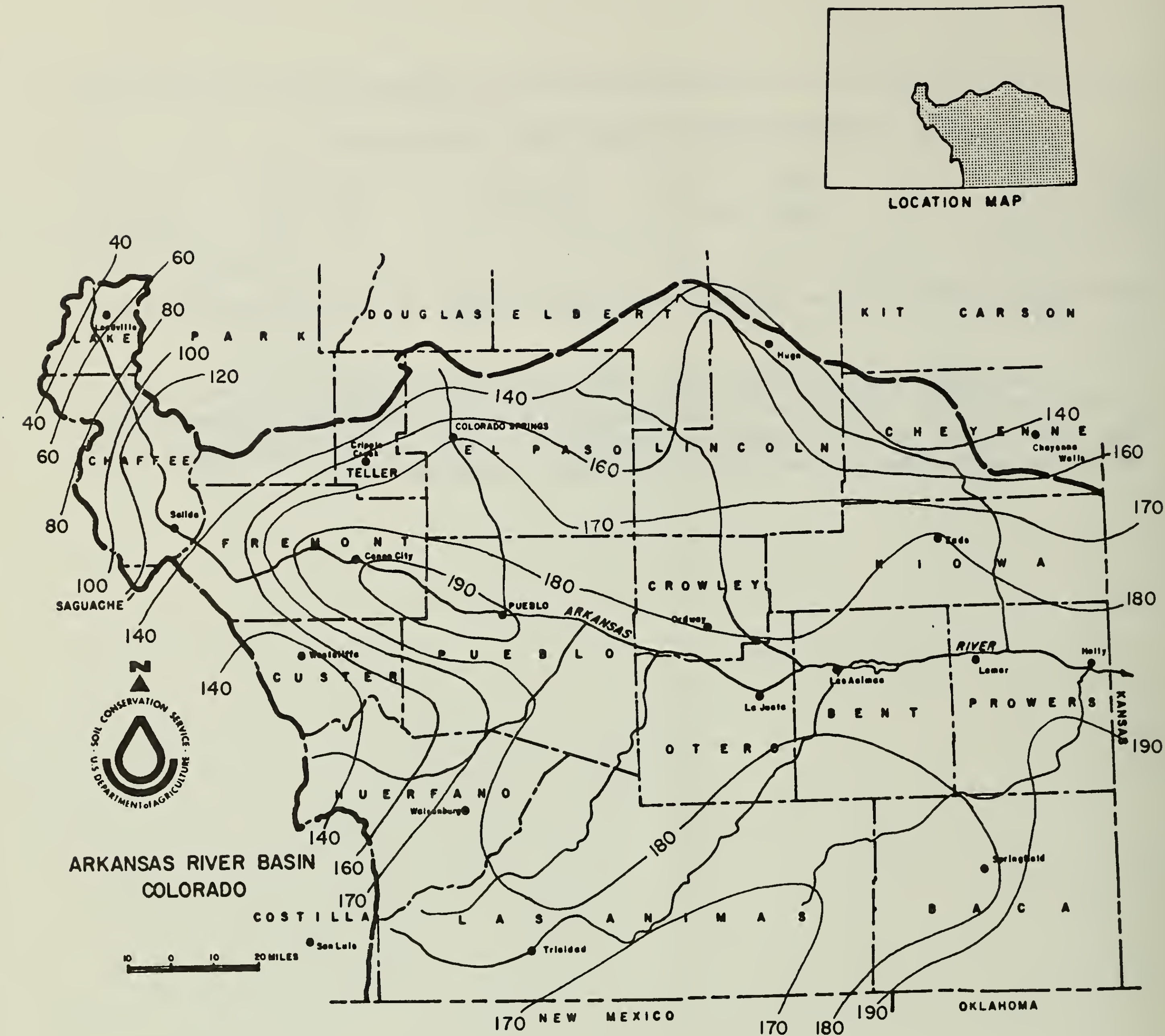
Month	Leadville	Canon City	Las Animas	Lamar
		-Mean Temperature °F-		
January	18.1	36.7	30.0	29.3
February	19.1	39.0	35.2	34.5
March	22.2	42.0	41.2	40.3
April	31.4	51.8	53.9	52.8
May	41.8	60.8	63.4	62.8
June	50.6	69.5	72.9	72.6
July	56.6	75.7	78.1	78.1
August	54.9	73.9	76.1	76.1
September	48.7	66.2	67.6	67.1
October	38.9	56.4	55.5	55.0
November	26.3	45.0	40.7	40.3
December	19.4	39.0	32.4	31.7
Annual	35.7	54.7	53.9	53.4


LEGEND
1931–60 Average Annual Precipitation
Inches
9-12
12-16
16-20
20-30
30-45
Average Annual Precipitation
LOCATION MAP
AVERAGE ANNUAL PRECIPITATION
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
SCALE 1:1,125,000
Source:
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
Thematic detail compiled by state staff.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
NEW MEXICO
OKLAHOMA
KANSAS
COLORADO SPRINGS
PUEBLO
Canon City
Trinidad
Walsenburg
La Junta
Lamar
Springfield
COMANCHE NATIONAL GRASSLAND

- Average Date of Fall Frost Occurrences -				
32°	Sept. 7	Oct. 14	Oct. 8	Oct. 9
28°	Sept. 18	Oct. 25	Oct. 18	Oct. 18

Source: Climates of the States, and Climatography of the United States No. 81 - Colorado

In the upper part of the basin, the growing season dictates that grass pasture and hay, alfalfa and spring grains are the predominant crops grown. The lower basin growing season is conducive to growing such additional crops as corn, vegetables, sugar beets, dry beans, potatoes, etc.



COLORADO STATIONS	No. of Years	Duration Days	
		32°	28°
Buena Vista	24	90	125
Colorado Springs	29	146	170
Eads	23	154	181
Limon	28	141	162
Pueblo	30	167	191
Rocky Ford	30	160	183
San Luis Lake	5	93	131
Springfield 8-S	3	169	175
Trinidad	28	156	179
Westcliffe	19	90	122

Figure A-3 Duration (days) for Frost Free Season (28° F)

Source: "Arkansas-White-Red River Basins, Part II Sec. 17 Availability, Use, and Control of Water."

WATER

Surface Water

The basic average water supply to the basin is shown in Table A-3. This supply varies widely from year to year depending on the winter snow pack in the mountains. The water supply for 1975 was used for irrigation system analysis therefore streamflow values for that year are shown in Table A-5, along with long-term averages. Table A-6 shows seasonal distribution of the water supply. In general, more than 60 percent of the average annual runoff occurs during April through July, and 20 percent during August through October.

Winter Snow is major
Source of Water Supply

Trans-Basin Diversions are a significant addition to the basin water supply. The Fryingpan-Arkansas project is the largest of these diversion systems. This project is an extensive system of canals, tunnels, and reservoirs for collecting and transporting water from the west side of the Continental Divide to the Arkansas Basins. This is a multi-purpose project which serves a variety of users, including agriculture. Several detailed references are available for those who desire more information on this project.

Table A-4 is a summary of trans-mountain diversions for the 1975 water year.

Table A-3 - Estimated Annual Water Supply
Pueblo, Colorado, to Colorado-Kansas State Line

Arkansas River Basin, Colorado

	Acre-Feet
Water Supply:	
Streamflow at Pueblo (77-year average)	514,000
Tributary inflow	320,000
Precipitation	300,000
Groundwater inflow	55,000
Total supply (rounded)	1,200,000

Source: Water-Management studies of a stream-aquifer system, Arkansas River Valley, Colorado. By O. James Taylor and Richard R. Luchey.

Table A-4 - Trans-Mountain Diversion Into
Arkansas River Basin For Water Year
October 1974 to September 1975
Arkansas River Basin, Colorado

Ditch or Tunnel	System	Total Acre Feet
Busk-Ivanhoe Tunnel	Frying Pan	7,100
Columbine Ditch	Eagle River	2,000
Ewing Ditch	Eagle River	1,140
Wurtz Ditch	Eagle River	3,430
Twin Lakes Tunnel	Roaring Fork	49,540
Larkspur Ditch	Tomichi Creek	328
Hoosier Pass Tunnel	Colo River Basin	8,460
Homestake Tunnel	Colo River Basin	59,870
Charles H. Bousted Tunnel	Colo River Basin	36,870

Source: "Thirty-Second Annual Report of the Upper Colorado River Commission"

Table A-5 - Water Supply

Arkansas River Basin, Colorado

Stream and Station	Runoff - Ac. Ft. 1975 (Avg. Year)	Runoff - Ac. Ft. Avg. for Period of Record to 1979	Station No.
Ark. R. near Malta	205,400	173,200	837
Ark. R. at Buena Vista	394,400	362,200	872
Ark. R. at Salida	500,500	455,000	915
Ark. R. at Canon City	573,200	518,000	960
Ark. R. near Pueblo	497,200	513,700 1/	995
Fountain C. at Security	32,380	39,630	1058
Fountain C. at Pueblo	25,720	38,690	1065
Ark. R. near Nepesta	463,000	495,600 1/	1170
Apishapa R. near Fowler	8,830	21,880	1195
Ark. R. at La Junta	120,100	176,800 1/	1230
Purgatoire R. at Madrid	34,850	33,110	1242
Purgatoire R. near Las Animas	4,540	84,040	1285
Ark. R. below John Martin	91,820	153,600 2/	1305
Big Sandy near Lamar	3,190	8,620	1341
Ark. R. near Coolidge, Kansas	35,290	132,600 3/	1375

1/ Period of record prior to Pueblo Reservoir (1973).
2/ Period 1949-79 adjusted for storage in John Martin Reservoir.
3/ Period 1951-70 subsequent to completion of John Martin Reservoir

Source: Water Resource Data for Colorado, U.S. Geological Survey

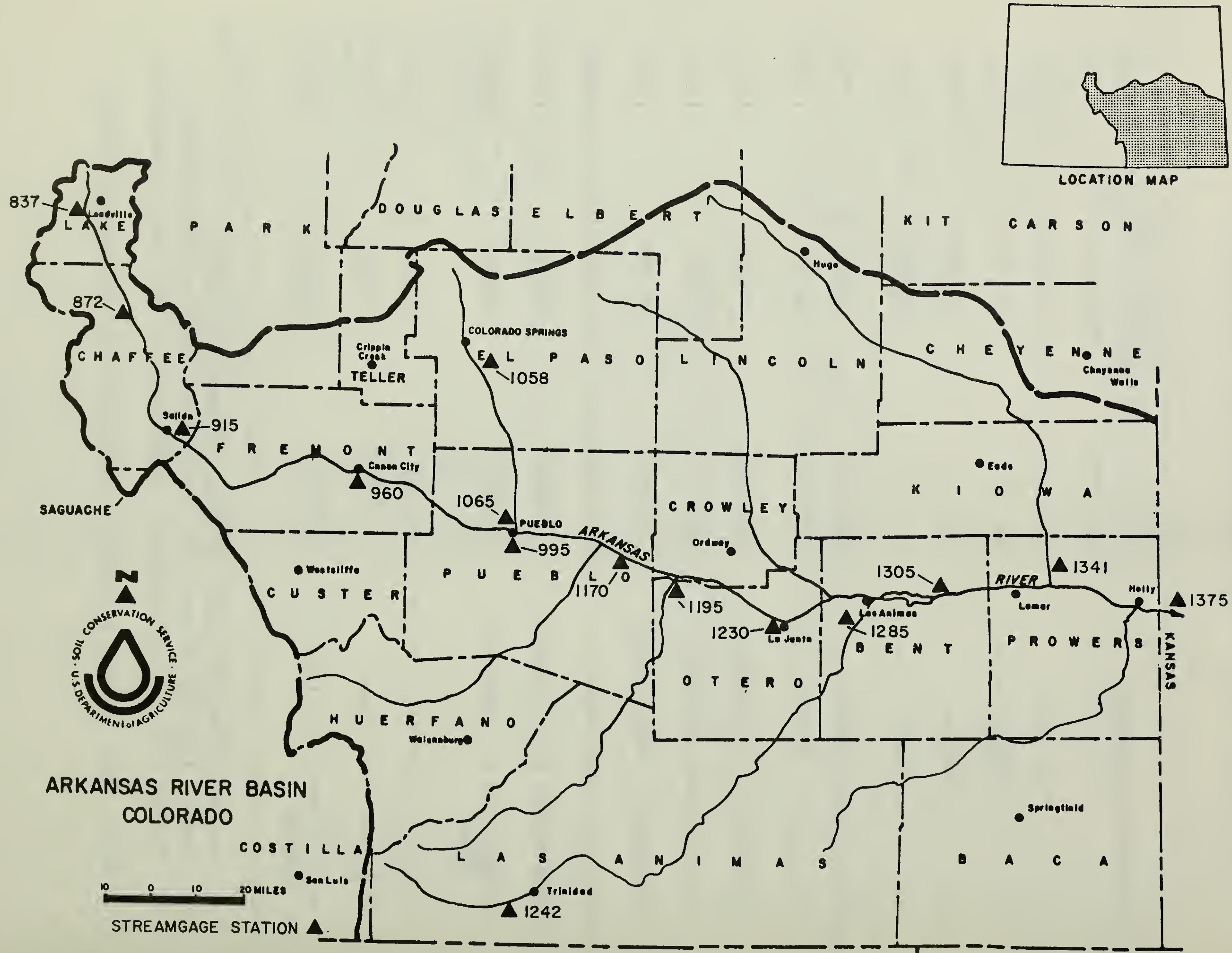


Figure A-4 STREAMGAGE STATIONS

Table A-6 - Seasonal Runoff of Arkansas River

Runoff Characteristics of Arkansas River at Colorado-Kansas State Line

Monthly Runoff of Maximum and Minimum Water Years of Record					
	Runoff in Acre-Feet			Runoff in Acre-Feet	
Month	Maximum Year 1942	Minimum Year 1940	Month	Maximum Year 1942	Minimum Year 1940
Nov.	61,400	1,100	May	324,000	4,900
Dec.	28,000	1,400	June	231,500	7,400
Jan.	33,000	1,500	July	43,800	700
Feb.	29,900	2,900	Aug.	70,800	2,100
Mar.	25,900	2,000	Sept	47,100	3,700
Apr.	394,800	1,500	Oct.	57,200	1,200

Source: "Arkansas-White-Red River Basins, Part II Section 17, Availability Use, and Control of Water" Interagency Committee (1955).

Arkansas River at Canon City, Colorado

Monthly Runoff of Maximum and Minimum Water Years of Record					
	Runoff in Acre-Feet			Runoff in Acre-Feet	
Month	Maximum Year 1891	Minimum Year 1940	Month	Maximum Year 1891	Minimum Year 1940
Oct.	32,660	10,260	April	50,990	6,410
Nov.	31,060	10,720	May	123,700	36,330
Dec.	30,870	12,550	June	195,800	55,230
Jan.	26,510	17,060	July	90,280	29,140
Feb.	26,310	13,700	Aug.	58,490	20,480
Mar.	36,040	13,340	Sept.	28,140	13,650

Source: "Arkansas-White-Red River Basins, Part II Section 17, availability Use, and Control of Water" Interagency Committee (1955)

Lakes and reservoirs in the basin serve an important function of controlling natural runoff. Runoff from snowmelt generally peaks during the month of May and early June, but peak demand for water generally occurs in July and August. Storage is used to meet part of the demand. Table A-7 shows a listing of reservoirs with storage capabilities. The larger reservoirs are used to carry over stored water from high runoff years to drought years. Capacities shown in Table A-7 do not reflect water supply, but simply a capability to regulate seasonal and annual runoff. Use of these bodies of water is predominantly for irrigation. In addition, some also serve as recreation, fish and wildlife, flood control and/or other purposes.

The Arkansas River is an inter-state stream and therefore governed by a compact. The Arkansas River compact between Colorado and Kansas was executed in 1948. It provides operating criteria for John Martin Reservoir which was completed in 1943.

Colorado statutes also provide for appropriation of water for instream flows and natural lake levels to protect the Natural Environment. To date there have been such appropriations made for 500 miles of streams and 84 natural lakes, totaling 16,000 acre feet of water in the basin.

Groundwater

There are three major aquifers in the basin: (1) Valley fill in the valleys of the Arkansas River and its major tributaries, (2) Ogallala formation underlying the high plains, and (3) Dakota Sandstone underlying the major portion of the basin east of the foothills. The area of main concern for this study is the valley fill along the Arkansas River and tributaries. This aquifer generally consists of sand and gravel to depths 100 feet along the main stem near Holly.

This aquifer is very productive with some large capacity wells producing nearly 2000 gallons per minute. There are about 3000 large capacity wells between Pueblo and the state line. Figure A-5 shows a recent history of groundwater withdrawals and figure A-6 is a map of groundwater availability.

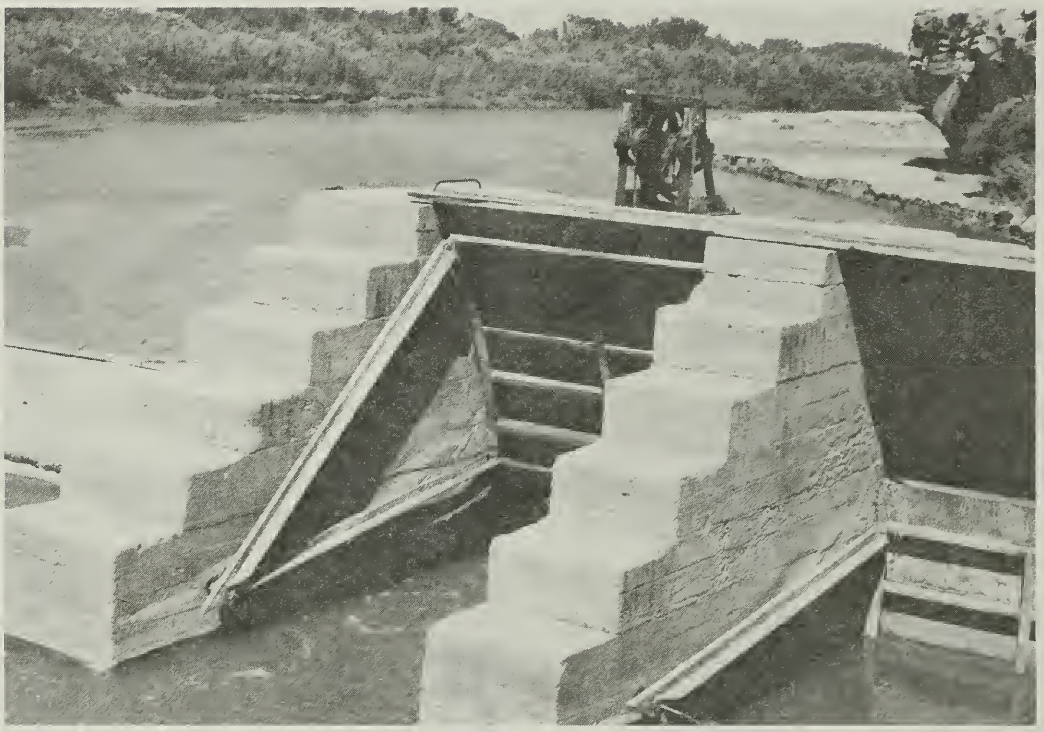
Diversions

Irrigation

Diverted water is applied to crop and pasture land in the basin through some 2,000 ditches and canals. In this study, 114 of these canals were inventoried and 32 were determined to have possible project action, as defined in Chapter 2.

Table A-6 - Irrigation Lakes And Reservoirs In Colorado
Arkansas River Basin, Colorado

Name	County	Type of Dam	Maximum Height (ft)	Surface Area (ac)	Capacity Acre Feet
Adobe	Bent	Earth	38	5,147	70,870
Antonio D. Valdez	Huerfano	Earth	42	300	4,880
Brush Hollow	Fremont	Earth	95	186	4,186
Campbell	Huerfano	Earth	60	157	3,650
Clear Creek	Chaffee	Earth	80	407	11,206
Crystal Creek	Teller	Dis. Granite	93	136	5,330
Cucharas Valley	Huerfano	Rockfill	125	1,470	40,210
De Weese-Dye	Custer	Concrete	48	208	2,763
Dotson	Pueblo	Earth	32	321	4,680
Dye	Otero	Earth	40	276	7,986
Fountain Valley No. 2	El Paso	Earth	60	427	5,076
Glen Park	El Paso	Concrete Arch	57	11	148
Holbrook No. 1	Otero	Earth	21	673	7,472
Horse Creek	Otero	Earth	28	2,603	27,050
John Martin (Caddoa)	Bent	Con-Earth	150	17,500	655,000
King (out of commis.)	Prowers	Earth	15	1,552	18,274
Kit Carson	Cheyenne	Earth	40	2,017	40,200
Lake Henry	Crowley	Earth	24	1,120	9,916
Lake Meredith	Crowley	Earth	15	3,220	26,028
Lake Oehm	Huerfano	Earth	25	206	4,880
Lincoln County No. 1	Lincoln	Earth	30	568	5,940
Lincoln County No. 2	Lincoln	Earth	30	491	4,480
Manitou	El Paso	Concrete	60	16	300
Model	Las Animas	Earth	39	1,198	20,350
Nee-Granda	Kiowa	Earth	25	3,490	23,040
Nee-Noshe	Kiowa	Earth	25	3,696	60,618
Nee So Pah	Kiowa	Earth	15	3,537	23,458
North Catamount Creek	Teller	Earth	140	2,260	6,644
Prairie Land & Irr. No. 1	Otero	Earth	16	790	5,360
Queen	Kiowa	Earth	25	1,930	23,040
Red Rock	Pueblo	Earth	102	320	12,867
Skaguay	Teller	Dis. Granite	79	114	3,080
South Catamount Creek	Teller	Earth	90	118	3,935
St. Charles No. 3	Pueblo	Earth	62.5	435	4,686
Sugar Loaf	Lake	Earth	38	818	17,416
Swink No. 1	Otero	Earth	40	455	6,320
Timpas Creek No. 2	Otero	Earth	25	300	3,000
Twin Lakes	Lake	Earth	28	2,273	53,259
Two Buttes	Baca and Prowers	Earth	106	1,798	40,910
Pueblo	Pueblo	Earth	185	5,700	357,700
Trinidad	Las Animas	Rock-Earth			158,500



Irrigation Diversion
Structure on the
Arkansas River

Table A-8 shows diversions for those canals studied. The year 1975, was determined to be a near average water year. In general, the amount diverted to these systems averaged 2.03 acre feet per acre for 400,500 acres served (114 canals). Supplemental pump water to these croplands provides an additional 0.29 acre feet per acre.

The surface diversion data was summarized from records in the Colorado State Engineers Office. This information was not developed for the entire basin because of the large number of ditches and canals involved.

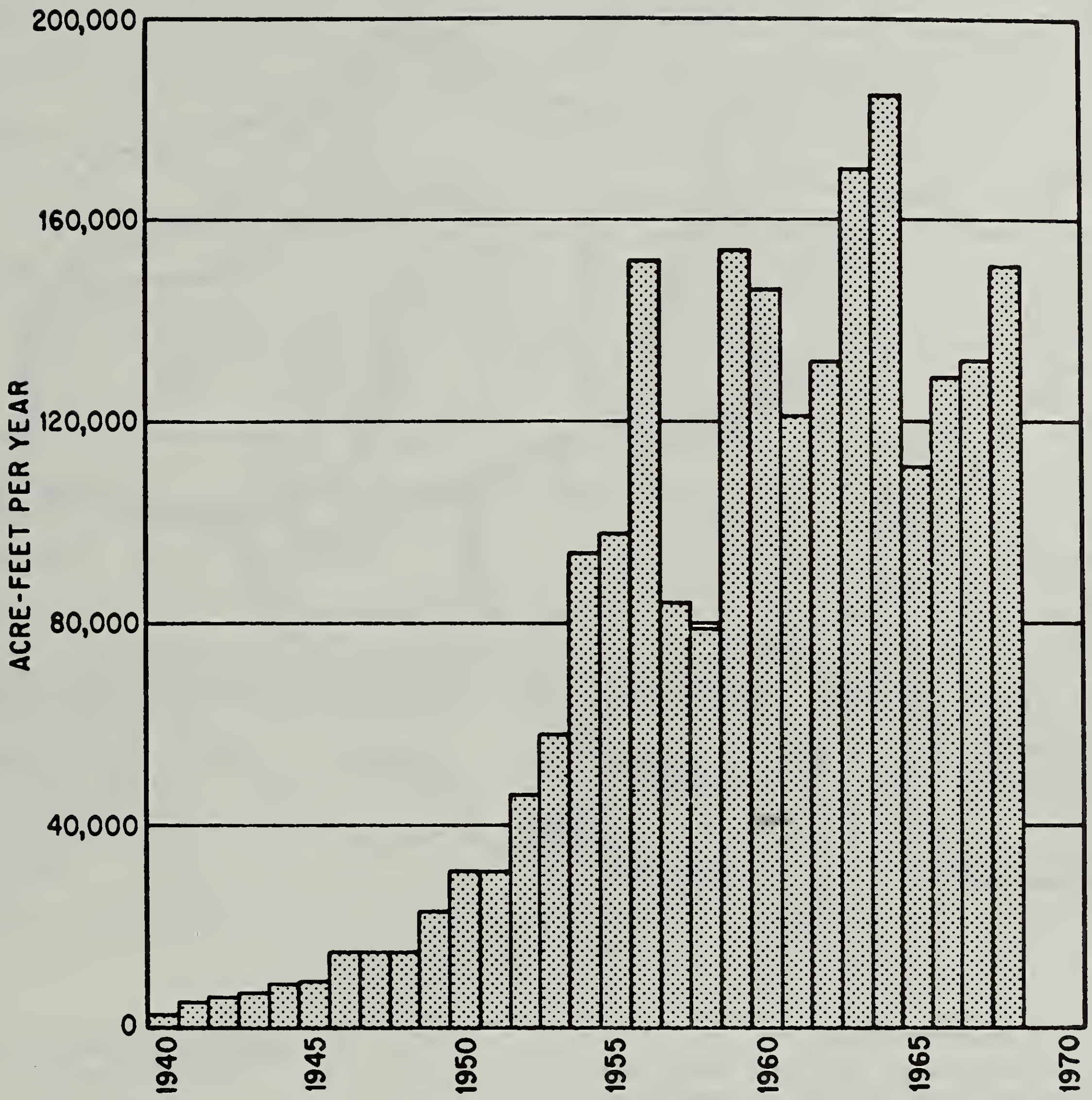
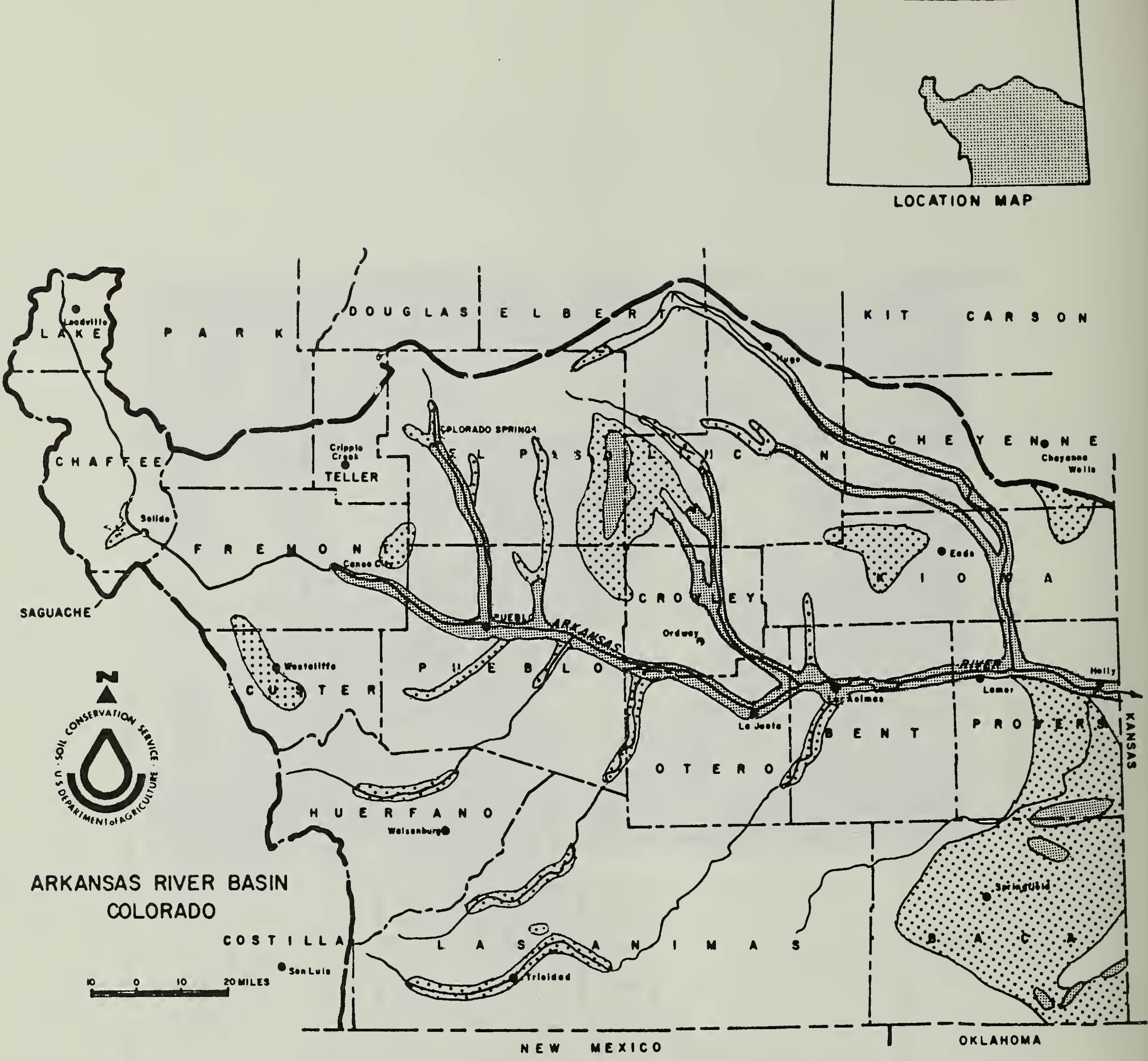


Figure A-5 **Ground-water withdrawal by irrigation wells.**

Source: "Ground Water Basic-Data Release No. 21"–U.S. Geological Survey, 1970.



LIMITS OF YIELD

Areas in which properly located (as by test drilling) and properly constructed wells generally are capable of yielding amounts of water within the limits specified, which is of a chemical quality generally satisfactory for most ordinary uses (excludes local areas in which large yields of salty or otherwise highly mineralized ground water may be available).

Does not indicate total quantity of ground water that may be safely developed perennially from any given area or ground-water reservoir; determinations of total quantity generally can be made only on basis of special investigations of particular areas.

QUANTITY GENERALLY AVAILABLE PER WELL, AS QUALIFIED

More than 500 gallons per minute

50–500 gallons per minute

Less than 50 gallons per minute; water table discontinuous or absent, or data on depth incomplete

Figure A-6 GROUNDWATER AVAILABILITY

Source: "Arkansas-White-Red River Basins, Part II Sec. 17 Availability, Use, and Control of Water."

Table A-8 1975 Irrigation Diversions
Arkansas River Basin, Colorado

Reach	Acre Served	Diverted AF	Pumped AF
10	4,860	18,807	45
11	17,903	78,072	0
12	15,844	86,965	0
13	4,020	8,124	0
14	109,314	185,772	32,264
15	550	591	35
16	13,921	10,374	0
17	142,547	276,342	56,135
18	2,691	3,746	150
19	26,628	52,666	370
67	62,183	93,191	23,762
Total 1/	400,461	814,650	112,761
Total 2/	313,087	560,500	106,600

1/ For 114 Canal Systems Inventoried.
2/ For 32 Canal Systems Having Viable Alternatives, no reach values given.

Source: 1975 Diversion Records of Colorado State Engineer.

Soils

The general soil map locates soil with similar characteristics and suitability within the basin, (see plate - soils map). Broad characteristics and relationships can then be used to interpret the potential of soils for agricultural, recreational, commercial and industrial uses. Problems of erosion, sediment yield, land use and future development are interrelated with soils and their distribution.

The General Soils Map was prepared by delineating 42 mapping units that differ from each other in the kinds of soils that are present. Soils in each mapping unit form patterns that are repeated from place to place.

Mapping units were defined and described according to requirements imposed by the map scale and criteria from "Soil Taxonomy" published December 1975. The soil map unit numbers in this report correspond to the soil map unit numbers of "Soils of Colorado" published July 1977, by CSU Experiment Station - Bulletin 566S.

Soils association numbers were used by the work group in preparation of reports and computer models. The Index for Soil Maps (Table A-9) shows the relationship of the soil association numbers to the mapping units.

Soil mapping units were placed in seven major groups for purposes of broad interpretation. Dominant characteristics of each mapping unit are given in Table A-10.

Natural Basin Features

The headwaters of the Arkansas Basin drain from the high peaks of three major mountain ranges which intersect in a narrow region at the center of the State. This part of the basin is nearly surrounded by the Saguache Range on the west and parts of the Gore and Mosquito Ranges on the north and east, respectively. Because these mountains receive a tremendous amount of snowfall in the winter, this uppermost area produces most of the water for the entire basin. The Arkansas River, as such, begins near Leadville at the confluence of Tennessee Creek and the East Fork of the Arkansas River.

Below Leadville, the river flows into a narrow valley which gradually widens south of Riverside all the way to Salida, forming grassy parks which are used as irrigated pasture and rangeland. Buena Vista lies within Berrian Park, which is nearly 18 miles long and 4 miles wide. Other similar parks are near Salida. These high plains and parks are bordered by the towering Collegiate Peaks on the west and a 10,000 foot divide on the east. Many tributary streams converge into the Arkansas River from these bordering ranges.

LEGEND

GROUP I — ALFISOLS

BORALFS

- 1 Typic Cryoboralfs, skeletal-Rock Outcrop: sloping to steep
- 3 Typic Eutroboralfs, clayey-Rock Outcrop: steep
- 4 Psammentic Eutroboralfs-Aridic Haploborolls: loamy, gently sloping and sloping

GROUP II — ARIDISOLS

ARGIDS

- 10 Ustollic Haplargids: loamy; nearly level and gently sloping
- 11 Ustollic Haplargids-Ustic Torriorthents (shallow): loamy; gently sloping to steep
- 12 Ustollic Haplargids, loamy-Rock Outcrop: gently sloping to steep
- 13 Ustollic Haplargids, silty-Ustollic Haplargids, loamy-Ustic Torriorthents, silty: nearly level to sloping
- 14 Ustollic Haplargids, clayey-Ustollic Haplargids, silty-Ustollic Paleargids, clayey: nearly level and gently sloping
- 15 Ustollic Haplargids, clayey-Ustic Torriorthents, loamy (shallow): gently sloping to steep
- 18 Ustollic Natrargids, clayey-Ustollic Haplargids, loamy: nearly level to sloping

ORTHIDS

- 24 Lithic Camborthids-Lithic Ustic Torriorthents: loamy, steep
- 25 Usteric Camborthids: clayey; nearly level
- 26 Ustollic Camborthids-Ustic Torriorthents (shallow): clayey, nearly level to sloping

GROUP III — ENTISOLS

FLUVENTS

- 30 Ustic Torrifluvents: loamy; nearly level and gently sloping
- 33 Ustic Torrifluvents-Typic Fluvaquents: loamy, nearly level

ORTHENTS

- 37 Ustic Torriorthents-Ustollic Calciorthids: loamy; nearly level
- 40 Ustic Torriorthents, silty-Lithic Ustic Torriorthents, loamy: gently sloping
- 42 Lithic Ustic Torriorthents, loamy-Rock Outcrop: gently sloping to steep

GROUP IV

ORTHENTS

- 12 Lithic Cryorthents, skeletal-Rock Outcrop: steep
- 41 Lithic Ustic Torriorthents-Ustic Torriorthents: loamy, sloping to steep

GROUP V

PSAMMENTS

- 45 Ustic Torripsamments: gently sloping to steep
- 46 Ustic Torripsamments-Ustollic Haplargids, loamy: gently sloping to moderately steep

GROUP VI — INCEPTISOLS

UMBREPTS

- 47 Pergelic Cryumbrepts, skeletal-Pergelic Cryochrepts, skeletal-Rock Outcrop: sloping to steep

GROUP VII — MOLLISOLS

AQUOLLS

- 49 Typic Cryaquolls-Argic Cryaquolls, loamy-Cumulic Cryaquolls: loamy; nearly level and gently sloping

BOROLLS

- 50 Aridic Argiborolls-Lithic Argiborolls: skeletal; sloping to steep
- 53 Aridic Calciborolls, skeletal-Aridic Calciborolls, loamy: sloping to steep
- 55 Typic Cryoborolls, loamy-Rock Outcrop: sloping to steep
- 56 Typic Cryoborolls, clayey-Typic Cryoboralfs, skeletal: moderately steep and steep
- 57 Typic Cryoborolls-Typic Cryorthents: clayey; sloping to steep
- 58 Argic Cryoborolls-Typic Cryoborolls: loamy; gently sloping to steep
- 60 Aridic Haploborolls, loamy-Torriorthentic Haploborolls, loamy-Aridic Argiborolls, clayey: gently sloping to steep
- 61 Lithic Haploborolls, skeletal-Rock Outcrop: moderately steep and steep

GROUP VIII

USTOLLS

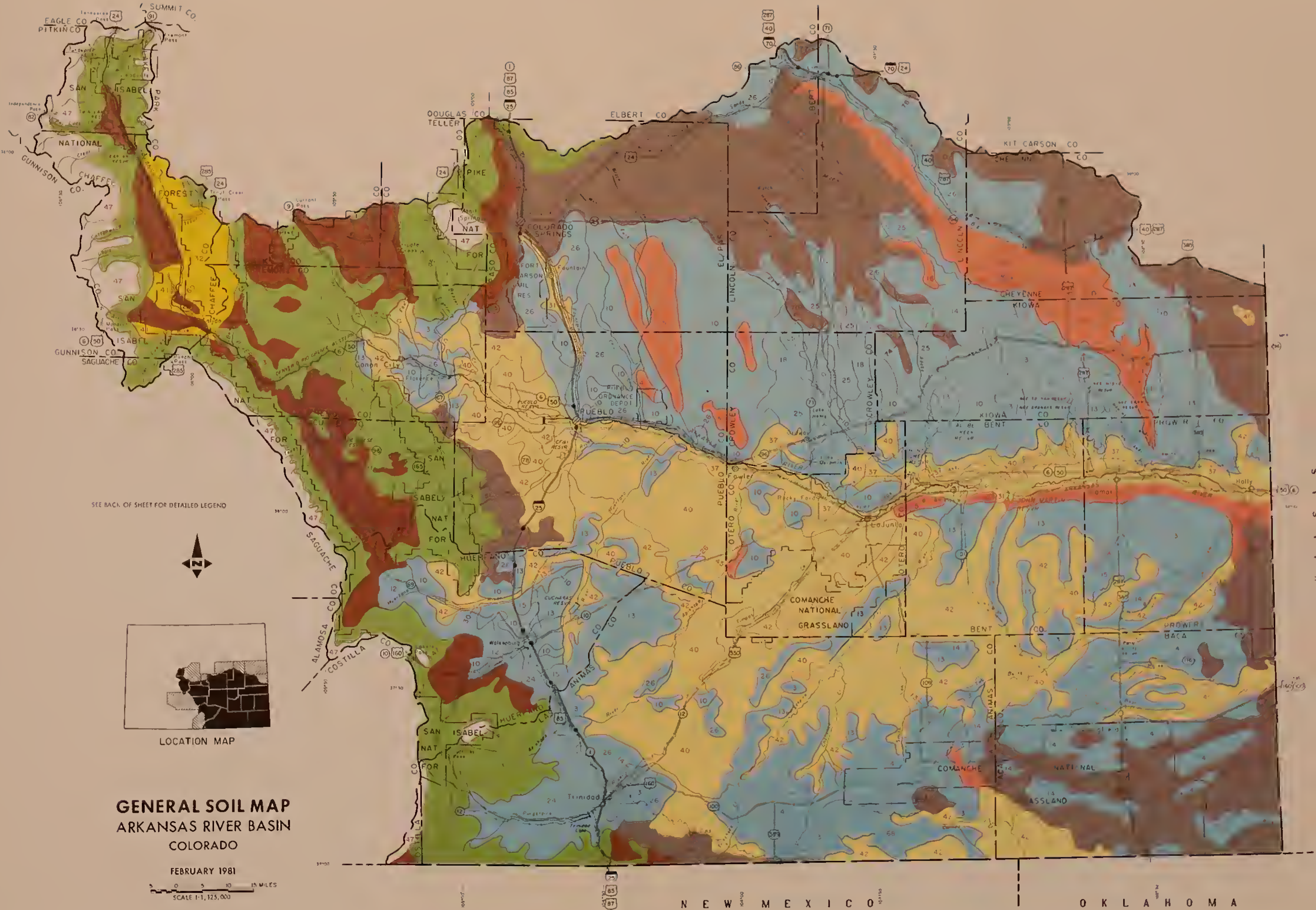
- 64 Aridic Argiustolls-Ustollic Haplargids: loamy; nearly level to sloping.
- 67 Aridic Argiustolls-Aridic Haplustolls: loamy; gently sloping to moderately steep
- 68 Aridic Argiustolls-Lithic Haplustolls: loamy; gently sloping to steep
- 69 Aridic Argiustolls, loamy-Torriorthentic Haplustolls, sandy: nearly level and gently sloping
- 70 Aridic Argiustolls, loamy-Aridic Paleustolls, clayey: nearly level and gently sloping
- 71 Aridic Argiustolls, clayey-Ustollic Haplargids, loamy: nearly level
- 74 Pachic Argiustolls-Aridic Argiustolls: clayey and silty; nearly level
- 75 Torrertic Argiustolls-Ustic Torriorthents (shallow): clayey; gently sloping to steep
- 77 Aridic Paleustolls-Ustollic Haplargids: clayey; nearly level to sloping
- 78 Aridic Paleustolls, clayey-Ustollic Paleargids, silty-Ustic Torriorthents, silty: nearly level to gently sloping

The soil bodies delineated on the "General Soil Map of Colorado" are called "Soil Map Units." Each one of these map units represents an area containing more than one different kind of soil. Only the major or important soils in each map unit are described. Different kinds of soils are closely associated and characteristically occur together within particular types of landscape settings. It is very important to remember that the soil map units are not grouped according to similar or like soils.

The first part of the name of a soil map unit is that of a Soil Subgroup. A Subgroup is one of the classes of soils described and defined in "Soil Taxonomy, A Basic System of Soil Classification for Making and Interpreting Soil Surveys." Terms describing the broad soil textural classes, amounts of rock fragments and slopes complete the name.

This map was made by combining delineations on more detailed soil maps available from the Soil Conservation Service and by predicting soil boundaries in areas where more detailed maps are not available.

Various temperature regimes are represented by using two shades of a color.



GENERAL SOIL MAP
ARKANSAS RIVER BASIN
COLORADO

FEBRUARY 1981

Source
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

Table A-9 - Index For Soils Maps
Mapping Units to Association Numbers

Arkansas River Basin, Colorado

Mapping Unit July 1977 Soils of Colorado	Association Number 1972 Colorado-Counties-General Soil Map
1	9,49,51,76
3	8,9,34,40,49,55
4	37,38
10	10,46
11	45,89
12	93,136
13	1,3,8,9,34,46,47,59,82,93
14	9,82
15	4,21,78
18	32,100
24	46,59,82,93
25	22
26	18,22,24,28,40,41,47,61,73,82
30	46,47,93,100
31	7,22,24
32	49,63,64
37	6,13,39
40	8,9,12,19,34,47,82
41	69,133
42	3,9,46
45	5
46	88,148
47	33,48,49,62
49	119
50	120,182
53	65,70
55	50,51,68,128,137
56	98
57	97
58	49,119
60	52,53,55,56,66,67,70,116,138
61	26
64	11,35,36,55
67	38,43
68	19,147,163
69	24,29
70	20
71	23,24,31,39
74	2,81
75	22,23,43,84
77	73,87
78	27

Table A-10 - Dominant Characteristics of Soil Mapping Units
Arkansas River Basin, Colorado

Group	Map Unit (No)	Percent of Basin (%)	Elevation (ft.)	Mean Annual Precip. (in)	Mean Annual Soil Temp (°F)	Frost-free Period (days)	Plant Cover (type)	Soil Depth	Parent Material	Slope Percent	Major Land Use	Potential for Irrigation
I (green)	1	8.3	7,500-11,500	20-40	35-45	0-75	Trees	moderately deep	weathered materials	5-65	Recreation Wildlife	None
	3	3.4	7,000-9,000	15-20	43-47	75-105	Trees, Grasses	shallow to moderate	weathered materials	30-50	Range Homesite	None
	4	0.3	6,500-7,500	20	45	100-125	Trees, Grasses	moderately deep	weathered materials	0-25	Homesite Range	None
II (blue)	10	8.8	4,000-7,000	10-75	47-55	90-165	Grasses	deep	alluvium	0-5	Range	Moderate
	11	0.4	3,500-5,500	15	50-55	140-170	Grasses	shallow to deep	weathered materials	5-10	Range	Low
	12	0.5	5,000-8,000	10-15	47-55	90-165	Trees, Grasses	shallow to deep	weathered materials	5-25	Range Wildlife Recreation	None
	13	10.5	3,500-6,000	10-15	48-55	100-165	Grasses	deep	wind deposits	0-15	Range, Dry Cropland, Irrigated Cropland	Moderate
	14	5.7	3,500-6,000	13	50-55	145-165	Grasses	deep	alluvium, wind deposits	0-5	Dry Cropland Range	Moderate
	15	0.4	4,000-6,000	13	50-55	140-165	Grasses	shallow to deep	weathered materials	5-25	Dry cropland Range	Low
	18	0.9	4,500-5,000	12	50-55	130-165	Grasses	deep	alluvium wind deposits	0-5	Range	Moderate
	24	1.6	6,000-8,000	15	50-55	110-155	Grasses	shallow	weathered material	20-50	Range	None
	25	2.5	4,500-6,000	13	50-55	140-165	Grasses	moderated deep	weathered materials	0-2	Range Irrigated cropland	Low
	26	5.1	4,500-7,000	15	47-55	135-165	Grasses	shallow	weathered materials	0-15	Range	None

Table A-10 (Cont'd)

Group	Map Unit (No)	Percent of Basin (%)	Elevation (ft.)	Mean Annual Precip. (in)	Mean Annual Soil Temp (°F)	Frost-free Period (days)	Plant Cover (type)	Soil Depth	Parent Material	Slope Percent	Major Land Use	Potential for Irrigation
III (light yellow)	30	0.1	6,000-7,000	15	50-55	110-140	Shrubs, Trees, Grasses	deep	alluvium	0-5	Range, Irrigated cropland, Dry cropland	Moderate
	31	0.9	3,400-4,000	15	55	145-165	Grasses	deep	alluvium	0-2	Irrigated cropland, Wildlife, Range	Moderate to high
	37	2.2	3,500-5,000	15	55	145-165	Grasses	deep	alluvium wind deposits	0-2	Irrigated cropland, Range	Moderate to high
	40	10.1	3,500-6,000	13	47-55	150-165	Grasses	moderately deep	weathered materials	0-5	Range, Dry cropland	Low to moderate
	42	10.4	3,500-7,500	10-15	50-55	125-165	Grasses, Trees	shallow	weathered materials	2-50	Range Wildlife Recreation	Low to moderate
IV (yellow)	32	0.9	8,000-11,000	16	35-40	30-80	Trees, Shrubs	shallow	weathered materials	30-50	Wildlife Watershed Recreation	None
	41	0.3	6,000-9,000	14	40-47	75-125	Shrubs, Grasses	shallow	mixed alluvium	5-50	Range Wildlife Recreation	Low to moderate
V (orange)	45	2.8	3,500-6,000	12-18	50-55	140-165	Grasses	deep	wind deposits	3-30	Range Irrigated cropland	Low
	46	1.5	4,500-5,500	13	50-55	150-160	Grasses	deep	wind deposits	2-25	Range Irrigated cropland	Low
VI (white)	47	2.3	11,000-14,500	30-50	30-35	0	Forbs, Shrubs, Grasses	shallow	weathered materials	2-50	Wildlife Recreation Watershed	None
VII (brown)	49	0.1	7,800-10,000	12-20	35-45	30-90	Sedge Rushes Grasses	shallow to moderately deep	mixed alluvium	0-5	Irrigated cropland Wildlife	Low
	50	0.1	8,000-11,000	10-20	40-45	30-75	Trees, Grasses	shallow	weathered materials	2-50	Range wildlife Recreation	None

Table A-10 (Cont'd)

Group	Map Unit (No)	Percent of Basin (%)	Elevation (ft.)	Mean Annual Precip. (in)	Mean Annual Soil Temp (°F)	Frost-free Period (days)	Plant Cover (type)	Soil Depth	Parent Material	Slope Percent	Major Land Use	Potential for Irrigation
	53	0.2	7,000–9,000	14	47	75–100	Shrubs, Grasses	moderately deep	coarse textured alluvium	2–50	Range Irrigated cropland	Low
	55	1.51	8,000–10,500	15–20	38–42	25–65	Grasses	shallow to moderately deep	coarse textured alluvium	2–50	Range Irrigated cropland	Low
	56	0.02	7,000–11,500	15–25	35–42	20–85	Trees	shallow to moderately deep	weathered materials	15–50	Range Wildlife Recreation	None
	57	0.06	8,000–10,000	15–20	40–45	45–85	Trees, Shrubs	shallow to moderately deep	coarse textured alluvium	3–50	Range Wildlife	None
	58	1.6	8,000–11,000	15–30	38–45	30–75	Shrubs, Grasses	moderately deep	coarse textured alluvium	2–50	Range Wildlife	None
	60	1.0	6,000–8,500	10–15	40–47	75–125	Shrubs, Grasses	moderately deep	weathered materials	2–45	Range Irrigated cropland	Low
	61	0.5	5,500–8,000	15–24	42–47	80–150	Shrubs, Grasses	shallow	weathered materials	15–50	Range Wildlife Recreation	None
VIII (light brown)	64	2.8	3,500–5,500	13–16	50–55	150–165	Grasses	moderately deep	coarse textured alluvium	0–15	Dry cropland Range	Low
	67	0.4	4,000–7,000	13–17	47–55	130–160	Grasses	moderately deep	weathered materials	2–30	Irrigated cropland Range	Moderate
	68	1.0	6,000–8,000	16–20	47–55	155	Grasses Trees	shallow to moderately deep	weathered materials	2–40	Range Dry cropland	Low
	69	2.2	5,500–6,800	14–17	47–55	135–160	Grasses	deep	wind deposits	0–5	Range Dry cropland	Moderate
	70	4.31	4,000–6,000	13–17	50–55	140–160	Grasses	deep	alluvium	0–5	Range Dry cropland	Moderate
	71	1.0	3,500–7,000	12–16	47–55	145–165	Grasses	deep	alluvium wind deposits	0–2	Irrigated cropland Range	Moderate to high

Table A-10 (Cont'd)

Group	Map Unit (No)	Percent of Basin (%)	Elevation (ft.)	Mean Annual Precip. (in)	Mean Annual Soil Temp (°F)	Frost-free Period (days)	Plant Cover (type)	Soil Depth	Parent Material	Slope Percent	Major Land Use	Potential for Irrigation
	74	1.6	3,500-4,500	15-18	50-55	140-165	Grasses	deep	wind deposits	0-2	Dry cropland Range, Irr. cropland	Moderate to high
	75	0.3	5,500-6,500	15	48-50	135-150	Grasses	shallow	weathered materials	0-50	Range Dry cropland	Moderate
	77	0.4	5,000-5,500	14	48-53	135-150	Grasses	moderately deep to deep	wind deposits alluvium	0-15	Irrigated cropland Dry cropland	Moderate to high
	78	1.0	4,200-5,200	12-17	50-55	140-155	Grasses	deep	wind deposits	0-5	Dry cropland Range	Low to moderate

Source: "Soils of Colorado, July 1977"

Near Salida, the river valley narrows once again and forms a deep narrow gorge. Just west of Canon City, the river passes through the spectacular Royal Gorge. The tributaries to this reach of the Arkansas, between Salida and Canon City, flow down from the eastern slope of the rugged Sangre de Cristo Mountains and from the mountains on the northern border of the Arkansas River Basin. The Sangre de Cristo produces much of the water for the southern portion of the Arkansas River drainage. East of Canon City, the Arkansas enters the Great Plains and winds along easterly toward the Colorado-Kansas border. This largest portion of the basin consists of gently rolling hills and native prairie. There are many tributaries in this portion of the basin, however, they do not produce sustained base flows characteristic of mountain streams. Some of these plains streams, such as the Purgatoire, Apishapa, and Huerfano Rivers have created canyons in the middle and upper reaches. Stream channel aggradation occurs where they confluence with the Arkansas River.

Physiographic Divisions are shown in figure A-7.

Geology

The Arkansas River Basin in Colorado lies in the Southern Rocky Mountain province and the Great Plains province, (see figure A-7). The western portion of the basin, Southern Rocky Mountain province, includes the headwaters of the Arkansas River which is composed mainly of ancient granitic and metamorphic rocks, but includes also Paleozoic sediments, Tertiary intrusive and extrusive rocks, Tertiary sediments, and glacial lake and stream deposits. The area was uplifted repeatedly and largely stripped of its cover of younger rocks by stream and glacial erosion. The rocks generally have been severely folded and faulted.

The eastern portion of the Arkansas River Basin in Colorado, Great Plains province, includes portions of three sections; the Colorado Piedmont, the Raton Section and the High Plains.

The Piedmont and Raton sections, the moderately dissected plains bordering the mountains, are composed largely of Cretaceous shale, chalk, limestone, and sandstone, but adjacent to the mountains are upturned beds of older Mesozoic and Paleozoic sediments, and there are small areas of Tertiary and Quatenary sediments and volcanic rocks. Near the mountains the rocks are sharply folded and somewhat faulted, elsewhere they are gently dipping and but slightly folded.

All the Great Plains section in the basin was once covered by a veneer of Tertiary silt, sand, and gravel laid down by streams from the mountains. This material has been stripped by erosion from the Piedmont and Raton sections, but several large patches remain as remnants of the High Plains, including several areas north of the Arkansas River and one in the south-eastern corner of the State. These remnants are composed mainly of the Ogallala formation, but locally include some younger deposits.

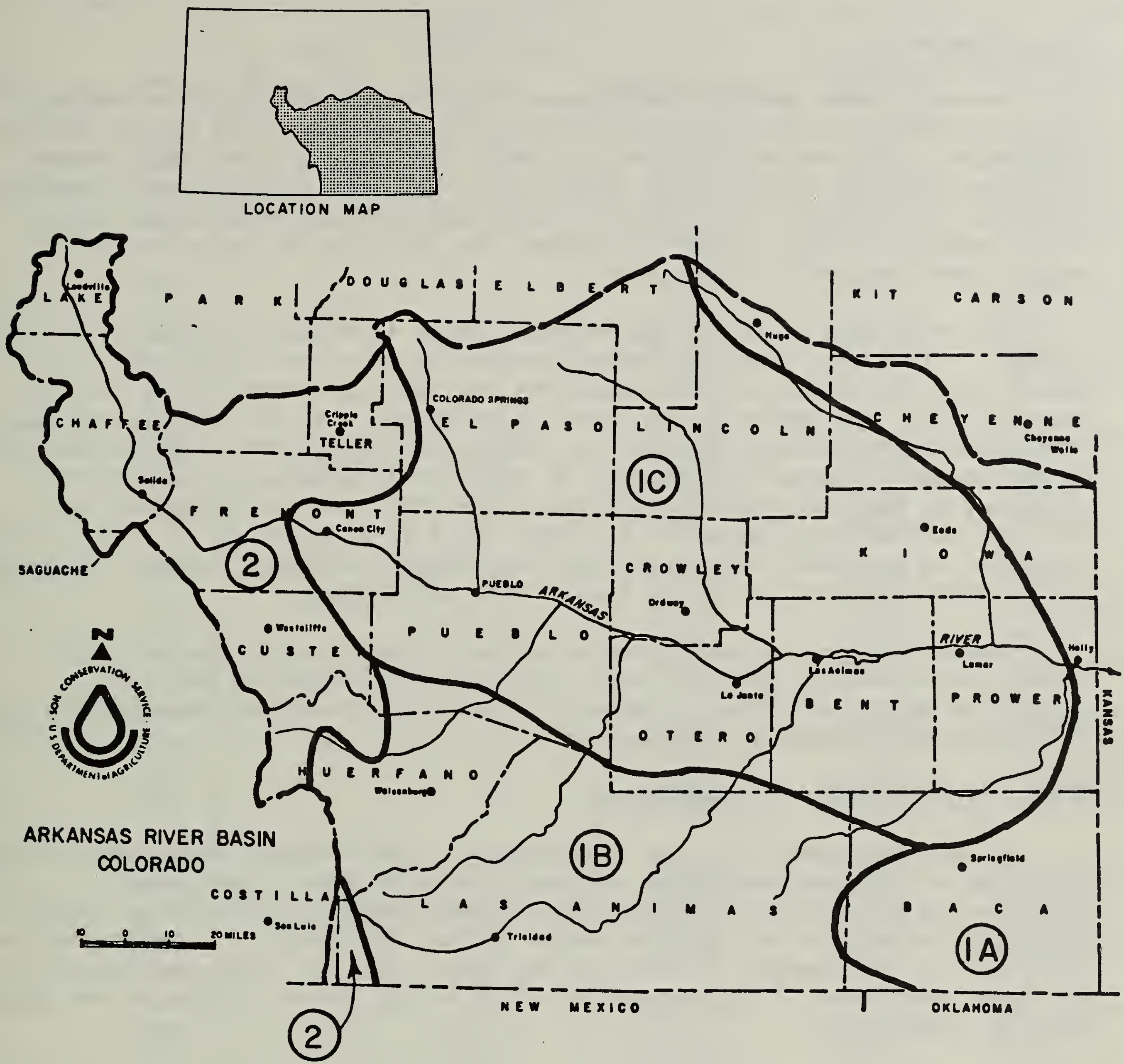


Figure A-7 **PHYSIOGRAPHIC DIVISIONS**

LEGEND

MAJOR DIVISION	PROVINCE	SECTION
1 Interior Plains	Great Plains	A High Plains B Raton C Colorado Piedmont
2 Rocky Mountain System	Southern Rocky Mountains	

Total Population

The total land area of the Arkansas River Basin is 27% of the entire State of Colorado. The 1980 Basin's population was about 20% of the State's population. The population density of both the Basin and the State showed increases over the fifteen year period, but the Basin's density was somewhat less than the State's. The Arkansas Basin and Colorado experienced similar growth rates from 1960 to 1980, although the State had slightly greater growth than the Basin, (Table A-11).

The total population in the Arkansas Basin increased steadily from 1960 to 1980. Similarly, the mean county population increased during that period, but the median county population was not only considerably smaller than the mean, the mediam value actually decreased over the fifteen years. This discrepancy between the mean and median values for the counties was due to the unusually large contribution to total Basin population made by two counties, El Paso and Pueblo. Together these two counties accounted for 66.4% of the Basin's population in 1960, 73.4% in 1970, 74.5% in 1975, 75.6% in 1980. In contrast, the county with the fewest residents, Custer County, contributed less than 1% to the Basin total population.

Several changes in population occurred in the Arkansas Basin in the twenty years between 1960 and 1980. Ten counties suffered a decline in population which was offset by growth in the eight remaining counties for an overall 45.6% increase in the Basin.

Urban 1/ And Rural 2/ Populations

Between 1960 and 1970, the populations in the Arkansas River Basin and the State of Colorado exhibited a dramatic drop in farm inhabitants countered by an equally dramatic rise in urban dwellers to yield an overall population growth in both region (Table A-12). The Basin's urban population increased 37.4% compared to 34.3% in the State, and the total population in the Basin increased 22.1% compared to 25.8% in the State. (More recent data were not available.)

1/ An URBAN POPULATION is defined by all persons living in (a) a place greater than 2,500 incorporated as cities and towns but excluding persons living in rural portions of extended cities; (b) unincorporated places greater than 2,500; (c) other territory incorporated or unincorporated included in urbanized areas, i.e. a central city or cities and surrounding closely settled territory.

2/ A RURAL POPULATION is defined as a population not classified as urban. A rural population is further subdivided into farm and rural non-farm categories. A farm population is defined by persons living in rural areas on (a) places of 10 or greater acres with sales of $50 or greater; (b) place less than 10 acres with sales of $250 or greater.

Table A-11 - The Population of the Arkansas River Basin, Colorado 1/

County	Year	Area: Sq. Mi.	Density Persons Per Sq. Mi.	Population	Change in Population Percent	Change in Population Period
Baca	1960		3	6,310	-10.1	1960-1970
	1970	2,563	2	5,674	+ 1.5	1970-1975
	1975		2	5,658	- 8.7	1960-1975
	1980		2	5,419	- 4.5	1970-1980
Bent	1960		5	7,419	-12.5	1960-1970
	1970	1,519	4	6,493	+ 2.1	1970-1975
	1975		4	6,631	-10.6	1960-1975
	1980		4	5,945	- 8.4	1970-1980
Chaffee	1960		8	8,298	+22.5	1960-1970
	1970	1,038	10	10,162	+16.7	1970-1975
	1975		11	11,863	+43.0	1960-1975
	1980		13	13,227	+30.2	1970-1980
Cheyenne	1960		2	2,789	-12.8	1960-1970
	1970	1,772	1	2,431	- 6.7	1970-1975
	1975		1	2,269	-18.6	1960-1975
	1980		1	2,153	-10.1	1970-1980
Crowley	1960		5	3,978	-22.4	1960-1970
	1970	802	4	3,086	+ 6.0	1970-1975
	1975		4	3,271	-17.8	1960-1975
	1980		4	2,988	- 3.2	1970-1980
Custer	1960		2	1,305	-17.7	1960-1970
	1970	737	2	1,074	+ 8.6	1970-1975
	1975		2	1,166	-10.7	1960-1975
	1980		2	1,528	+36.4	1970-1980
El Paso	1960		67	143,742	+64.2	1960-1970
	1970	2,157	109	235,972	+19.1	1970-1975
	1975		130	280,929	+95.4	1960-1975
	1980		143	309,424	+31.1	1970-1980
Fremont	1960		13	20,196	+ 8.6	1960-1970
	1970	1,561	14	21,942	+19.5	1970-1975
	1975		17	26,226	+29.9	1960-1975
	1980		18	28,676	+30.7	1970-1980
Huerfano	1960		5	7,867	-15.1	1960-1970
	1970	1,574	4	6,681	- 2.3	1970-1975
	1975		4	6,524	-17.1	1960-1975
	1980		4	6,440	- 2.3	1970-1980
Kiowa	1960		1	2,425	-18.2	1960-1970
	1970	1,767	1	1,983	+ 7.6	1970-1975
	1975		1	2,134	-12.0	1960-1975
	1980		1	1,936	- 4.6	1970-1980

Table A-11 (cont.)

County	Year	Area: Sq. Mi.	Density per Sq. Mi.	Population	Change in Population Percent	Period
Lake	1960		19	7,101	+16.6	1960-1970
	1970	379	22	8,282	+ 0.3	1970-1975
	1975		22	8,305	+17.0	1960-1975
	1980		23	8,830	+ 6.6	1970-1980
Las Animas	1960		4	19,983	-12.2	1960-1970
	1970	4,794	3	15,744	+ 2.0	1970-1975
	1975		3	16,057	-19.6	1960-1975
	1980		3	14,897	- 5.4	1970-1980
Lincoln	1960		2	5,310	- 8.9	1960-1970
	1970	2,593	2	4,836	+ 2.9	1970-1975
	1975		2	4,977	- 6.3	1960-1975
	1980		2	4,663	- 3.6	1970-1980
Otero	1960		19	24,128	- 2.5	1960-1970
	1970	1,254	19	23,523	+ 4.0	1970-1975
	1975		20	24,462	- 1.4	1960-1975
	1980		18	22,567	- 4.1	1970-1980
Prowers	1960		8	13,296	- 0.3	1960-1970
	1970	1,621	8	13,258	+ 4.2	1670-1975
	1975		9	13,821	+ 3.9	1960-1975
	1980		8	13,070	- 1.4	1970-1980
Pueblo	1960		49	118,707	- 0.4	1960-1970
	1970	2.405	49	118,238	+ 6.3	1970-1975
	1975		52	125,665	+ 5.9	1960-1975
	1980		52	125,972	+ 6.5	1970-1980
Teller	1960		5	2,495	+32.9	1960-1970
	1970	553	6	3,316	+72.5	1970-1975
	1975		10	5,720	+129.3	1960-1975
	1980		15	8,034	+142.3	1970-1980
Basin	1960		14	395,349	+22.1	1960-1970
	1970	29,089	17	482,695	+13.1	1970-1975
	1975		19	545,778	+28.0	1960-1975
	1980		20	575,769	+16.1	1970-1980
State	1960		17	1,753,947	+25.8	1960-1970
	1970	103,766	21	2,207,259	+15.1	1970-1975
	1975		24	2,541,311	+44.9	1960-1975
	1980		28	2,888,834	+23.5	1970-1980

Source: County and City Data Book, 1962, 1972, 1977, 1980, Bureau of the Census, U.S. Department of Commerce.

1/ Costilla,, Douglas, Elbert, Kit Carson, Park and Saquache Counties are not included as only a small portion of their land areas lie within the basin.

Except for the large decline in the farm population (Arkansas Basin: -40.2%; Colorado: -32.8%), the rural population showed dissimilar trends. The Basin's total rural population fell 12.0% in contrast to the slight 2.1% increase in the State. Similarly, the non-farm rural population in the Basin declined 4.0% while it rose 15.6% in the State.

While the total population of the Arkansas Basin rose from 1960 to 1970, the majority of the counties in the Basin (12 of 17) showed a decline in population. Of the five counties showing growth (El Paso, Chaffee, Fremont, Lake, and Teller), El Paso County accounts for nearly all of the Basin's population increase. Much of El Paso County's population growth (64.2%) stems from a dramatic increase in its urban population (91.3%), particularly in the growth of Colorado Springs. During the decade, the Basin's urban population rose 37.4% despite the fact that seven of the seventeen counties have no urban residents. Five counties actually experienced a decline in urban population, and five counties, El Paso, Fremont, Lake, Prowers, and Pueblo counties exhibited urban growth. The large urban areas in the Basin are in El Paso County (Colorado Springs) and Pueblo County (City of Pueblo).

The Basin's total rural population fell 12.0% from 1960 to 1970, and similarly, the rural population decreased in every county but three: Chaffee, (the only county to gain rural and lose urban residents), Lake, and Teller. The farm population declined 40.2% throughout the Basin, and Lake, the only county to experience growth in every population category, was the only county to show an increase in farm inhabitants. The non-farm rural population in the Arkansas Basin fell 4.0%, with eight counties showing increase and nine counties showing decreases.

Cities [3] And Urban Centers [4]

Colorado Springs and Pueblo are the two largest cities and urban centers in the Arkansas River Basin. Both cities exhibited growth in area and population during the twenty years from 1960 to 1980 (Table A-13). In

---

3 A CITY is defined as a political subdivision of a state within a defined area over which a municipal corporation with a population over 25,000 has been established.

4 An URBAN CENTER is defined as (a) a central city or cities and surrounding closely settled territory; (b) a central city greater than 50,000; (c) twin cities; (d) a surrounding closely settled territory is defined as (i) incorporated places greater than 2,500; (ii) incorporated places less than 2,500 if a closely settled area has 100 housing units or more; (iii) small parcels of land normally less than one square mile having a population density greater than 1,000 per square mile.

Table A-12 - Rural and Urban Population 1/
Arkansas River Basin, Colorado

Population County		Rural Non-farm	Rural Farm	Rural Total	Urban Total	County Total	Percent Rural	Percent Urban
Baca	1960	3,881	2,429	6,310	0	6,310	100.0	0.0
	1970	4,393	1,281	5,674	0	5,674	100.0	0.0
% Change	'60-'70	+13.2	-47.3	-10.1	0	-10.1		
Bent	1960	2,248	1,766	4,014	3,405	7,419	54.1	45.9
	1970	2,128	1,186	3,314	3,179	6,493	51.0	49.0
% Change	'60-'70	- 5.3	-32.8	-17.4	- 6.6	-12.5		
Chaffee	1960	3,178	556	2,734	4,564	8,298	45.0	55.0
	1970	5,538	280	5,818	4,344	10,162	57.3	42.7
% Change	'60-'70	+74.3	-49.6	+55.8	- 4.8	+22.5		
Cheyenne	1960	1,877	912	2,789	0	2,789	100.0	0.0
	1970	1,531	900	2,431	0	2,431	100.0	0.0
% Change	'60-'70	-18.4	- 1.3	-12.8	0	-12.8		
Crowley	1960	2,777	1,201	3,978	0	3,978	100.0	0.0
	1970	2,341	745	3,086	0	3,086	100.0	0.0
% Change	'60-'70	-15.7	-38.0	-22.4	0	-22.4		
Custer	1960	713	592	1,305	0	1,305	100.0	0.0
	1970	623	451	1,074	0	1,074	100.0	0.0
% Change	'60-'70	-12.6	-23.8	-17.7	0	-17.7		
El Paso	1960	32,198	2,300	34,498	109,244	143,742	24.0	76.0
	1970	25,808	1,181	26,989	208,983	235,972	11.4	88.6
% Change	'60-'70	-19.8	-48.7	-21.8	+91.3	+64.2		
Fremont	1960	7,251	1,151	8,402	11,794	20,196	41.6	58.4
	1970	6,372	719	7,091	14,851	21,942	32.2	67.7
% Change	'60-'70	-12.1	-37.5	-15.6	+25.9	+ 8.6		
Huerfano	1960	1,621	1,141	2,793	5,074	7,867	35.5	64.5
	1970	1,178	856	2,034	4,647	6,681	30.4	69.6
% Change	'60-'70	-27.3	-25.0	-27.3	- 8.4	-15.1		
Kiowa	1960	1,530	895	2,425	0	2,425	100.0	0.0
	1970	1,447	536	1,983	0	1,983	100.0	0.0
% Change	'60-'70	- 5.4	-40.1	-18.2	0	-18.2		

Table A-12 (cont.)

Population		Rural			Urban	County	Percent	Percent
County		Non-farm	Farm	Total	Total	Total	Rural	Urban
Lake	1960	3,032	64	3,096	4,005	7,101	43.6	56.4
	1970	3,486	447	3,933	4,349	8,282	47.5	52.5
% Change	'60-'70	+15.0	+598.4	+27.0	+ 8.6	+16.6		
Las Animas	1960	7,234	2,058	9,292	10,691	19,983	46.5	53.5
	1970	4,988	809	5,797	9,947	15,744	36.8	63.2
% Change	'60-'70	-31.0	-60.7	-37.6	- 7.0	-21.2		
Lincoln	1960	3,234	2,076	5,310	0	5,310	100.0	0.0
	1970	3,671	1,165	4,836	0	4,836	100.0	0.0
% Change	'60-'70	+13.5	-43.9	- 8.9	0	- 8.9		
Otero	1960	7,842	3,330	11,171	12,957	24,128	46.3	53.7
	1970	9,123	1,649	10,772	12,751	23,523	45.8	54.2
% Change	'60-'70	+16.3	-50.5	- 3.6	- 1.6	- 2.5		
Prowers	1960	2,952	2,978	5,930	7,366	13,296	44.6	55.4
	1970	3,781	1,633	5,414	7,844	13,258	40.8	59.2
% Change	'60-'70	+28.1	-45.2	- 8.7	+ 6.5	- 0.3		
Pueblo	1960	11,989	3,324	15,313	103,394	118,707	12.9	87.1
	1970	12,369	2,230	14,599	103.639	118,238	12.3	87.7
% Change	'60-'70	+ 3.2	-32.9	- 4.7	+ 0.2	- 0.4		
Teller	1960	2,365	130	2,495	0	2,495	100.0	0.0
	1970	3,299	17	4,416	0	3,316	100.0	0.0
% Change	'60-'70	+39.5	-86.9	+32.9	0	+32.9		
Basin	1960	95,953	26,903	122,855	272,494	395,349	31.1	68.9
	1970	92,076	16.085	108,161	374,534	482,695	22.4	77.6
% Change	'60-'70	- 4.0	-40.2	-12.0	+37.4	+22.1		
State	1960	333,250	128,038	461,288	1,292,659	1,753,947	26.3	73.7
	1970	385,188	85,989	471,177	2,736,082	2,207,259	21.3	78.8
% Change	'60-'70	+15.6	-32.8	+ 2.1	+34.3	+25.8		

Sources: County and City Data Book, 1962, 1972, Bureau of the Census, U.S. Department of Commerce

1/ Costilla, Douglas, Elbert, Kit Carson, Park and Saquache Counties are not included as only a small portion of their land areas lie within the basin. 1980 data not available.

Table A-13 - Population of the Cities of Colorado Springs and Pueblo
Arkansas River Basin, Colorado

Year	City Proper					City plus Surrounding Urbanized Area				
		Population					Population			
	Area Sq. Mi.	Density per Sq. Mi.	Total	Percent of County	Percent of Basin	Area Sq. Mi.	Density per Sq. Mi.	Total	Percent of County	Percent of Basin
City of Colorado Springs (El Paso County)										
1960	16.7	4,203	70,194	48.8	17.8	29.3	3,420	100,220	69.7	25.3
1970	60.8	2,221	135,017	57.2	28.0	90.0	2,275	204,766	86.8	42.4
1975	84.7	2,120	179,584	63.9	32.9	N.A.	N.A.	N.A.	N.A.	N.A.
1980	N.A.	N.A.	215,150	69.5	37.4	N.A.	N.A.	N.A.	N.A.	N.A.
City of Pueblo (Pueblo County)										
1960	17.1	5,332	91,181	76.8	23.1	25.5	4,052	103,306	87.1	26.1
1970	22.5	4,331	97,453	82.4	20.2	32.0	3,279	103,300	87.4	21.4
1975	33.1	3,182	105,312	83.8	19.3	N.A.	N.A.	N.A.	N.A.	N.A.
1980	N.A.	N.A.	101,686	80.7	17.7	N.A.	N.A.	N.A.	N.A.	N.A.

N.A.: Data Not Available.

Source; County and City Data Book, 1962, 1972, 1977, 1980, Bureau of the Census, U.S. Department of Commerce.

1960, Pueblo was the largest city and urban center in the Basin, but in the next decade, Colorado Springs grew larger than Pueblo. Both cities grew rapidly between 1970 and 1980, but during the twenty years between 1960 and 1980, Colorado Springs' population increased 206.5% compared with Pueblo's 11.5% increase. During that period, Pueblo maintained a higher population density than Colorado Springs.

The populations of both cities account for a large proportion of the Arkansas Basin's population. Colorado Springs was responsible for nearly half or more of El Paso County's population from 1960 to 1980. Pueblo was responsible for over three fourths of Pueblo County's population during that period. Together the two cities accounted for over half of the Basin's population and if one were to consider the cities and their surrounding urbanized areas, their contributions are greater still.

USES OF RESOURCES

The basin area contains about 18,185,400 acres. There is a wide range of uses for the natural resources of the basin, typical of other areas of Colorado. Historically the area was predominantly grazed by livestock from the Kansas border to the high mountain passes. The development of irrigation water along the river by diversion, created a significant agriculture base for the area.

The mining of metallic ores and coal was very important until the 1920's. Currently the only significant activity occurs at Leadville and Cripple Creek.

Recreational use of land is important throughout the Basin but particularly in the foothills and mountain range to the west.

For the purpose of this study, however, the use of water and land, the ownership of land, and the agricultural production will be described in more detail.

Water Use

Water use budgets for this study were not made for the entire basin. However, a general summary for the Arkansas Basin is given in the "Colorado State Water Plan-Phase 1 Appraisal Report" (1974) as follows:

Arkansas Basin Depletions

	Ac. Ft.		%
Irrigation	704,000		73
M&I and Rural Domestic	58,000	(51.8 mgd)	6
Other	29,000		3
Outflow (1950-70 Avg.)	178,000		18
Total Depletions	969,000		100

Agriculture is by far the greatest consumptive user of water in the basin. The principle of re-use is very evident whereby return flows from one system contribute to the water supply of downstream systems. It is estimated that more than 85 percent of the water supply is consumed before it reaches the Kansas state line. As indicated in the preceding table, agriculture accounts for 73 percent of depletions.

Water Use by Irrigated
Cropland

In 1980 there were some 99 municipal water systems serving cities and towns in the Basin. Most cities and towns in the mountainous areas obtain their water from streams whereby communities east of Pueblo are dependent on groundwater sources.

The Colorado State Water Plan - Phase 1 Appraisal Report estimated that 58,000 acre feet of water is annually depleted from the Basin water supply for municipal and industrial purposes. Other studies suggest that about 50 percent of withdrawals for municipal and industrial use is consumed. Based on these estimates, 116,000 acre feet of withdrawal is necessary to provide the 58,000 acre feet of depletion estimated for the Basin.

The consumption of water by phreatophytes represents a significant portion of water used in the Basin. Data pertaining to this segment of water use is sparse, however some information is available from another study for the Arkansas River flood plain between Pueblo and the state line (Table A-14). This data does not include phreotophytes on tributaries, and intermixed with cropland away from the river. These off river areas have been included to some extent in this study. Phreatophyte and wetland areas associated with canal systems selected for this study were included in the inventories. Evapotranspiration rates were estimated for these areas and water use was accounted for in the water supply demands analyses, see Table I-2.

Table A-14 - Estimated Consumptive Use of Water by
Woody Phreatophytes, Arkansas River Bottom
Pueblo to State Line

Arkansas River Basin, Colorado

	Pueblo to Nepesta		Nepesta to La Junta		La Junta to Las Animas		Las Animas to John Martin Dam		John Martin Dam to Colo. Kans. Line	
	(Acres)	(Ac-Ft)	(Acres)	(Ac-Ft)	(Acres)	(Ac-Ft)	(Acres)	(Ac-Ft)	(Acres)	(Ac-Ft)
Total	5,170	13,500	6,310	17,900	3,660	10,900	3,660	10,900	8,620	19,700

Total Area = 27,420 acres

Total Estimated Consumptive Use = 72,900 acre-feet

* Totals are rounded to the nearest 10 acres and 100 acre-feet.

Wetlands Use Water Also

Alternative future conditions that include changes in phreatophyte and wetland acreages can be compared with the present condition to determine impacts on this segment of water use, see Tables II-3, and B-4 through B-9.

Land Use

Land use refers to the kind of activity for which any given parcel of land is being utilized. Since present land use conditions and activities exert such a strong influence on the type and extent of future development, it is necessary to recognize existing land usage as an important factor in the planning process, (see plate - Land Use).

The major acreage of land in the Basin, about 12,533,700 acres (69%) is used as native range and pastureland with livestock being the significant source of income throughout.

Many areas, particularly in the eastern two thirds of the Basin, are used for nonirrigated cropland production of winter wheat, forage and grain sorghum and to a lesser extent, corn, pinto beans and broom corn. This dry-land farming comprises about 2,246,300 acres or 12% of the basin.

Surface Irrigated Cropland

Sprinkler Irrigated Cropland

Irrigated Orchard

Table A-15 Land Use (Acres)

Arkansas River Basin, Colorado

	CROPLAND		PASTURE		RANGE	FOREST	WATER	URBAN 1/	OTHER 2/	TOTAL ACRES
	Irr.	Dry	Irr.	Dry				Trans.		
Baca	87,900	644,221	12,400	10,300	862,919	365	177	23,318		1,641,600
Bent	61,165	52,160	6.796	1,000	838,165		16,640	8,547	3,047	987,520
Chaffee	100	13,661	11,500	500	167,141	457,249	640	13,758	1,051	665,600
Cheyenne	1,280	83,200	160		598,250				960	683,850
Costilla					14,560	9,703				24,263
Crowley	7,200	71,506	24,400	1,000	408,645		5,760	1,169		519,680
Custer	1,500	1,200	14,300	600	233,332	201,998	640	18,750		472,320
Douglas						510				510
Elbert	1,840	163,560	800	11,000	199,907			921		378,028
El Paso	1,900	28,480	13,600	19,400	873,062	120,962	1,280	129,907	122,828	1,311,419
Fremont	11,139	400	6,900	500	630,611	312,328		25,242	12,560	999,680
Huerfano	600	42,164	11,600	1,400	673,021	265,481	1,280	13,836	1,818	1,011,200
Kiowa	9,700	581,995	1,100	3,500	536,419		12,160	2,044	1,242	1,148,160
Kit Carson					1,910					1,910
Lake			3,800	6,400	77,615	145,949	2,560	6,036	3,400	245,760
Las Animas	16,200	31,100	10,800	5,000	2,704,645	234,331	3,660	48,489	16,495	3,070,720
Lincoln	1,900	73,086	7,500	9,400	1,102,661		281	10,990	3,600	1,209,418
Otero	96,900	41,000	26,500	23,000	600,099	2,203	5,760	20,819	359	816,640
Park					147,266	36,524		290		184,080
Prowers	50,100	339,581	65,400	1,500	557,172	1,894	6,400	23,016	1,977	1,047,040
Pueblo	35,414	79,030	8,850	1,400	1,121,415	112,175	12,960	83,366	90,350	1,544,960
Saguache					311	22,106				22,417
Teller	200		700	3,700	85,007	85,000	640	22,090	1,278	198,615
	385,038	2,246,344	227,106	99,600	12,434,133	2,008,778	70,838	452,588	260,965	18,185,390

1/ Includes Municpal and Urban Build-Up Areas and Transportation.
2/ Includes Military Installations and Lands Designated for Recreation and Wildlife.

The wide benches along the Arkansas River are irrigated with river water and produce a variety of cash crops and forage crops. Pumping of underground water in the southeastern part of the basin adds significantly to the irrigated acreage. Irrigated crop and pastureland amounts to over 600,000 acres or 3.4% of the Basin. Feedlot operations are found scattered throughout the irrigated farmland.

The western part of the Basin is forestland (2,008,800 acres or 11% of the Basin). Much of this area of land is normally used for grazing of livestock and recreation. About 25% of the forestland is commercially used for timber and firewood.

The other land uses, including urban and built up areas, transportation (federal, state and county roads, railroads), military installations and land designated for recreation and wildlife habitat, make up about 713,600 acres or 4% of the basin. Water covers approximately 71,000 acres in lakes, reservoirs and streams. See Table A-15 for land use by county.

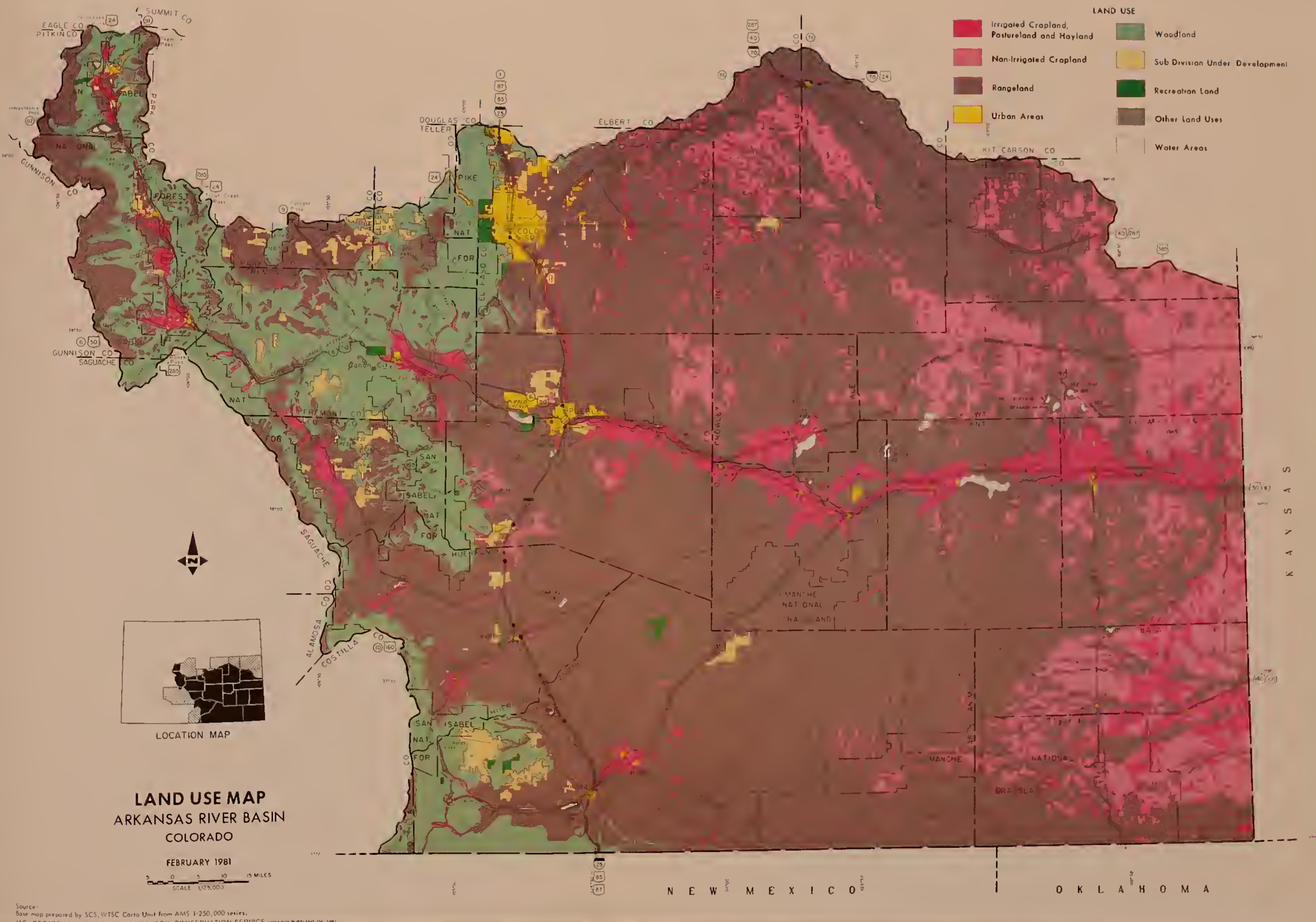
The conversion of agricultural land to non-agricultural uses is very evident in the state. It has a direct impact on the farmer and rancher but also affects others in terms of cost of food, cost of government, and pollution, population growth, energy development, economic stability and water policy. In the fast growing urban strip along the eastern foot of the Colorado front range, it is easy to find dramatic examples of conversion of agriculture land to other uses. In the past two decades this region alone has seen over 1.3 million acres go out of agricultural use. The patterns of urban growth are often diffused instead of clustered which magnifies the problem.

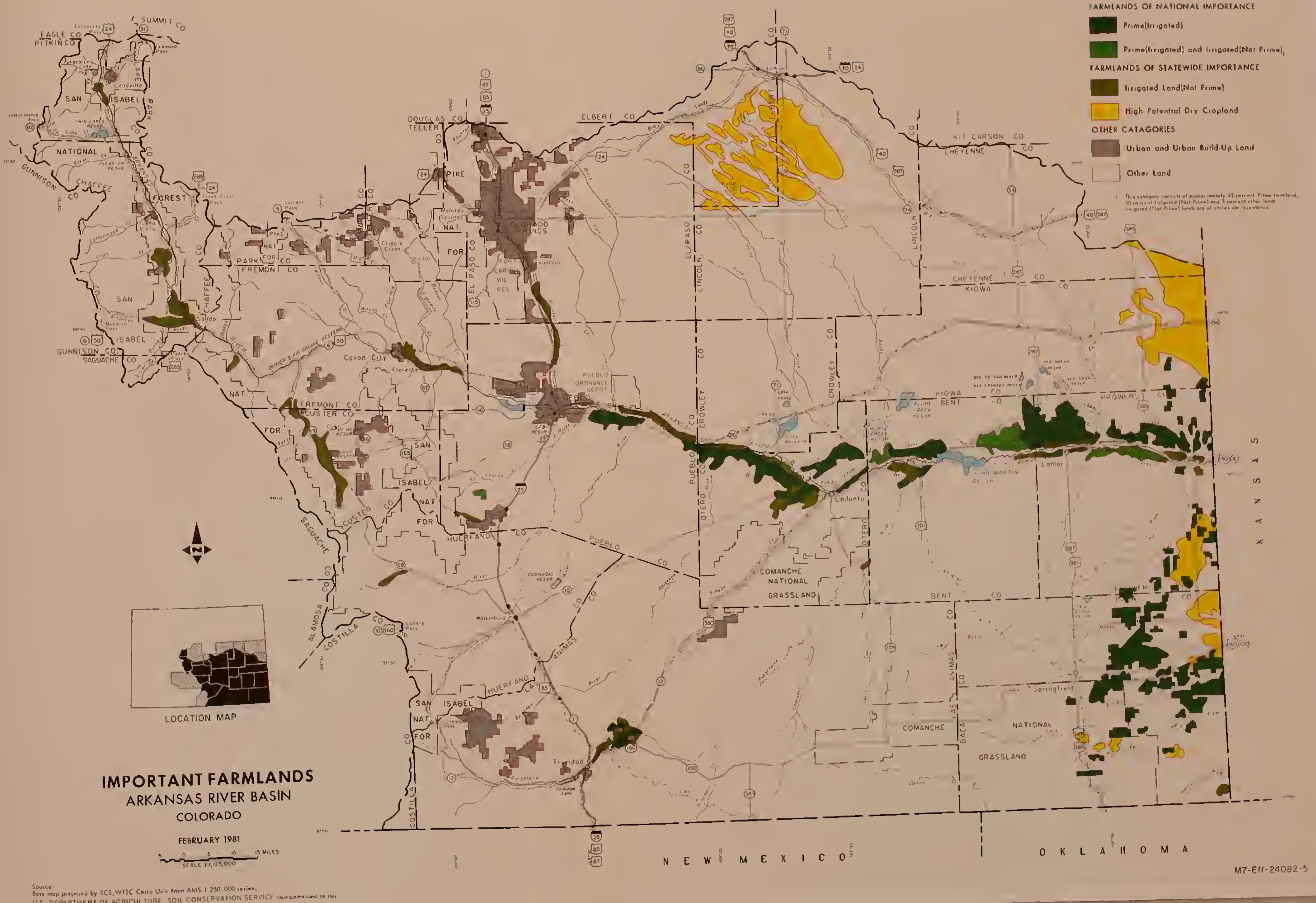
This study includes a map showing prime farmlands, (see plate - Important Farmland). Also the canal system inventories made for this study included a designation of prime farmland where applicable. Table II-2 shows a summary of this for present conditions, and for selected alternative conditions.

Land Ownership

Private ownership makes up 75% of the land area while 15% is public land, 8% is state land and 2% is county, municipal, transportation, and urban build-up areas. See table A-16, and Land Ownership plate for the ownership by counties.

The public lands are under the federal administration of the U.S. Forest Service, Bureau of Land Management, U.S. Corp of Engineers, Department of Transportation, Department of Army, Department of Air Force and the Bureau of Reclamation. Of the more important federal lands in the Basin, there is the U.S. Air Force Academy north of Colorado Springs and Fort Carson south of the city. The Department of Transportation's high speed test tracks is east of the city of Pueblo, and the Bureau of Reclamation's recently completed Pueblo Reservoir lies west of the city. John Martin Reservoir administered by the U.S. Corp. of Engineers is located at Hasty, Colorado.


LAND USE
Irrigated Cropland, Pastureland and Hayland
Non-Irrigated Cropland
Rangeland
Urban Areas
Woodland
Sub Division Under Development
Recreation Land
Other Land Uses
Water Areas
SUMMIT CO
EAGLE CO
PITKIN CO
GUNNISON CO
SAGUACHE CO
DOUGLAS CO
TELLER
ELBERT CO
KIT CARSON CO
PIKE
NAT
FOR
COLO SP
FREMONT CO
SAN ISABEL
HUERFANO
ALAMOSA
COSTILLA
KANSAS
NEW MEXICO
OKLAHOMA
LOCATION MAP
LAND USE MAP
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
15 MILES
Source:
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE


FARMLANDS OF NATIONAL IMPORTANCE
Prime(Irrigated)
Prime(Irrigated) and Irrigated(Not Prime)
FARMLANDS OF STATEWIDE IMPORTANCE
Irrigated Land(Not Prime)
High Potential Dry Cropland
OTHER CATAGORIES
Urban and Urban Build-Up Land
Other Land
IMPORTANT FARMLANDS
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
LOCATION MAP
SCALE 1:1,125,000
0 5 10 15 MILES
N E W M E X I C O
O K L A H O M A
K A N S A S
COLORADO SPRINGS
PUEBLO
PUEBLO ORDNANCE DEPOT
FORT CARSON MIL RES
COMANCHE NATIONAL GRASSLAND
Canon City
Florence
Leadville
Salida
Walsenburg
Trinidad
La Junta
Lamar
Springfield
ARKANSAS RIVER
EAGLE CO
PITKIN CO
SUMMIT CO
LAKE
PARK
CHAFFEE
FREMONT CO
CUSTER CO
HUERFANO
LAS ANIMAS
COSTILLA
ALAMOSA
SAGUACHE
GUNNISON CO
DOUGLAS CO
TELLER CO
EL PASO CO
ELBERT CO
LINCOLN CO
KIT CARSON CO
CHEYENNE CO
KIOWA CO
CROWLEY
OTERO CO
BENT CO
PROWERS
BACA CO
M7-EN-24082-5
Source:
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

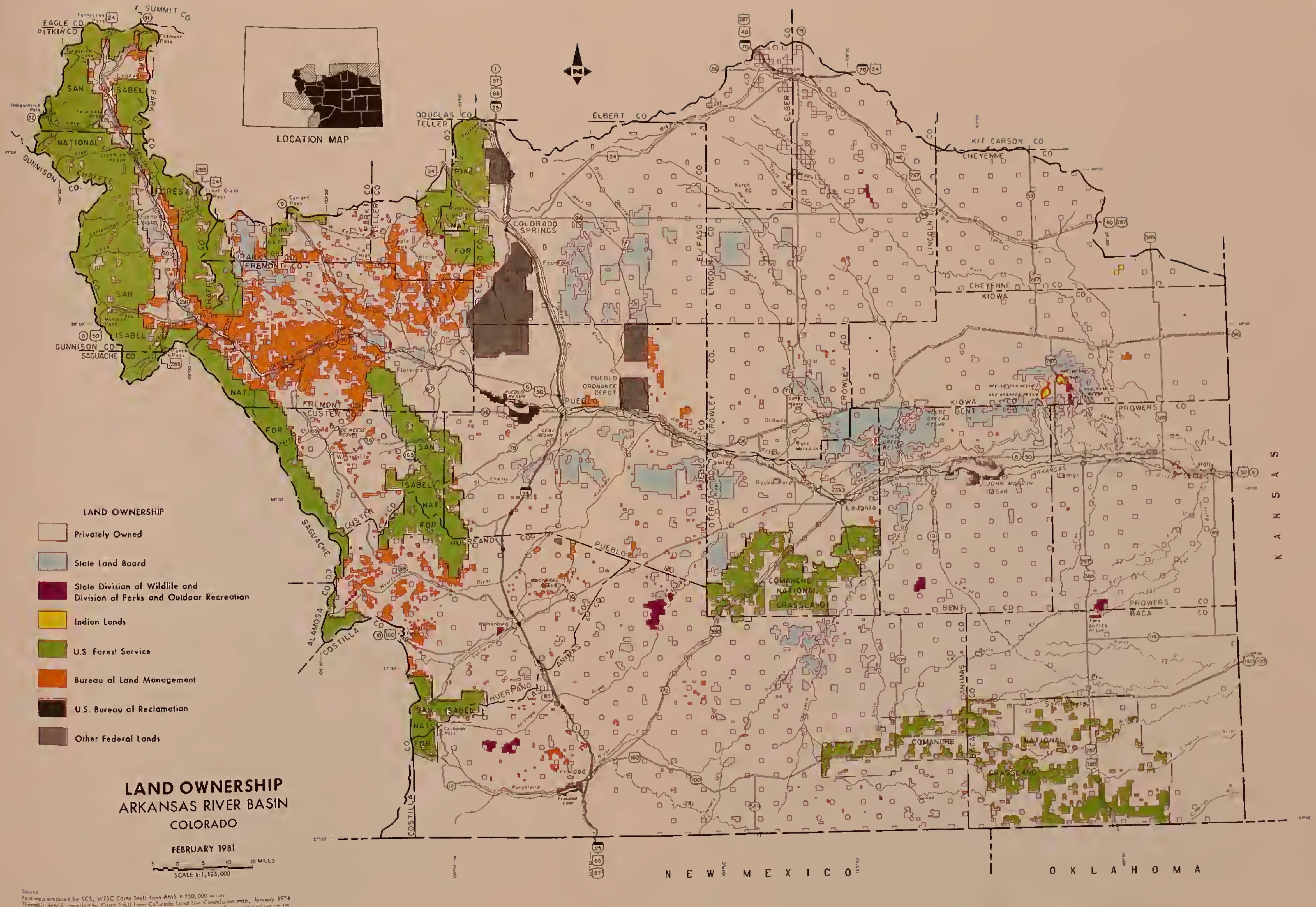

LAND OWNERSHIP
ARKANSAS RIVER BASIN
COLORADO
FEBRUARY 1981
SCALE 1:1,125,000
LAND OWNERSHIP
Privately Owned
State Land Board
State Division of Wildlife and Division of Parks and Outdoor Recreation
Indian Lands
U.S. Forest Service
Bureau of Land Management
U.S. Bureau of Reclamation
Other Federal Lands
LOCATION MAP
SUMMIT CO
EAGLE CO
PITKIN CO
LAKE CO
PARK CO
CHAFFEE CO
GUNNISON CO
SAGUACHE CO
DOUGLAS CO
TELLER CO
ELBERT CO
EL PASO CO
LINCOLN CO
KIT CARSON CO
CHEYENNE CO
KIOWA CO
FREMONT CO
CUSTER CO
PUEBLO CO
CROWLEY CO
OTERO CO
BENT CO
PROWERS CO
BACA CO
HUERFANO CO
LAS ANIMAS CO
ALAMOSA CO
COSTILLA CO
SAN ISABEL NATIONAL FOREST
PIKE NAT FOR
COMANCHE NATIONAL GRASSLAND
COLORADO SPRINGS
PUEBLO
PUEBLO ORDNANCE DEPOT
Florence
Walsenburg
Trinidad
Rocky Ford
La Junta
Las Animas
Lamar
Holly
Ordway
Fowler
JOHN MARTIN RESVR
ARKANSAS RIVER
KANSAS
NEW MEXICO
OKLAHOMA

Table A-16 - Land Ownership By Counties (Acres)

Arkansas River Basin, Colorado

County	Private	FEDERAL LAND USFS	BLM	Other 1/	STATE LAND Land Board	Division of Parks & Wildlife	Other 2/	Total in Basin 3/
Baca	1,370,044	204,923	210		42,928	177	23,318	1,641,600
Bent	823,020		400	9,833	142,673	3,047	8,547	987,520
Chaffee	126,722	452,511	51,455		20,103	1,051	13,758	665,600
Cheyenne	650,780			960	30,400		1,710	683,850
Costilla	24,263							24,263
Crowley	450,337		4,848		63,326		1,169	519,680
Custer	260,900	163,928	16,753		11,989		18,750	472,320
Douglas		510						510
Elbert	353,443				23,664		921	378,028
El Paso	783,913	98,135	3,880	103,742	191,842		129,907	1,311,419
Fremont	460,854	100,037	335,661	6,080	65,326	80	31,642	999,680
Huerfano	742,745	140,114	69,162		43,525	1,818	13,836	1,011,200
Kiowa	1,068,855		3,875		72,144	1,242	2,044	1,148,160
Kit Carson	1,910							1,910
Lake	65,798	148,869	22,478		2,579		6,036	245,760
Las Animas	2,669,081	84,119	88,419	3,400	163,997	13,215	48,489	3,070,720
Lincoln	1,071,958		3,764		118,825	3,881	10,990	1,209,418
Otero	505,501	161,324	7,729		120,908	359	20,819	816,640
Park	113,421	34,250	14,323		21,796		290	184,080
Prowers	976,316		1,064		44,667	1,977	23,016	1,047,040
Pueblo	1,079,172	32,913	22,069	106,910	232,450		71,446	1,544,960
Saguache	311	22,106						22,417
Teller	90,446	56,047	33,287		14,033	638	4,164	198,615
Total	13,689,790	1,699,786	679,377	230,925	1,427,175	27,485	430,852	18,185,390

1/ Depart. of Transportation; Air Force Academy; Army-Corp. of Eng. & Fort Carson; Dept. of Interior, Bureau of Reclamation; and Indian Land.
2/ Includes Highways & Roads, County & Municipal Lands, and Urban Build Up Lands.
3/ Includes Both Land and Water Areas.

Agricultural Sales and Product 1/

Sales

Table A-17 shows farm cash receipts for the Arkansas Basin and the State of Colorado. The two displays give both the original data and the data adjusted to the value of the dollar for 1966-1968.

The Basin and the State have shown a steady increase in total sales over the ten-year period, Table A-17. However, after adjustment for inflation, total sales in several counties were lower in 1974 and 1978 than in 1964.

While the Basin contained about one-quarter of the State's farmland, it contributed less than 20% of the State's total sales. Baca, Crowley, Otero, and Prowers counties had the largest while Lake and Teller counties the lowest total sales from 1964 to 1978.

Over the ten years the average sales per farm rose steadily in the Basin and the State, but the Basin average remained well below that for the State. Crowley, Lincoln, Prowers, and Otero County were the only counties in the Basin which were consistently higher in average sales per farm than the State. Chaffee, Custer, El Paso, Fremont, Huerfano, Kiowa, Las Animas, Pueblo, and Teller counties were significantly lower.

The average sales per acre rose steadily in both the Basin and the State, although the Basin figures were substantially below those for the State. In Crowley and Otero Counties, sales per acre were significantly higher than the State's average. In contrast, most of the other counties were significantly below the average sales per acre.

Crop and Livestock Sales - From 1964 to 1978, crop and livestock sales rose dramatically for Colorado and the Arkansas River Basin. The Basin's contribution increased steadily from 15% in 1964 to 18% in 1978, (Table A-18).

The proportion of sales attributed to crops versus livestock has fluctuated during the years in question. Livestock sales in 1978 were responsible for over 75% of the total farm sales for both the Arkansas Basin and Colorado. However, some counties have exhibited a trend towards an increasing proportion of crop sales. In 1964 less than 25% of the total sales in Cheyenne and Kiowa counties were from crops, but five years later that figure jumped to 35% and by 1978 50% of sales were from crops. However, livestock brought in more than 80% of the total income in Chaffee, Crowley, Custer, Fremont, Huerfano, Lake, Las Animas, Lincoln, Otero, and Teller counties.

1/ Source - Colorado Census of Agriculture.
Costilla, Douglas, ELbert, Kit Carson, Park and Saguaghe Counties are not included as only a small portion of their land areas lie within the basin.

Table A-17 - Farm Cash Receipts
Arkansas River Basin, Colorado

		Total Sales for All Farms		Average Sales Per Farm		Average Sales Per Acre	
County	Year	$1,000	1966-1968 $ 1/	$	1966-1968 $ 1/	$	1966-1968 $ 1/
Baca	1964	9,054	10,288	12,806	14,552	6.99	7.94
	69	25,570	23,245	33,165	30,150	19.77	17.97
	74	44,514	23,804	59,037	31,571	31.80	17.01
	78	54,221	26,975	75,307	37,465	40.68	20.37
Bent	1964	6,461	7,342	15,606	17,734	11.49	13.06
	69	11,600	10,546	31,693	28,812	13.97	12.70
	74	21,765	11,639	70,435	37,666	27.52	14.72
	78	73,640	11,760	70,357	35,003	32,38	16.15
Chaffee	1964	956	1,086	6,637	7,542	5.70	6.48
	69	1,649	1,499	12,309	11,190	14.43	13.12
	74	1,844	986	16,761	8,963	20.14	10.77
	78	2,754	1,370	18,990	9,448	30.83	15.40
Cheyenne	1964	3,587	4,076	11,209	12,738	3.71	4.22
	69	7,536	6,851	20,366	18,515	8.35	7.59
	74	19,554	10,457	53,719	28,727	21.62	11.56
	78	20,368	10,133	60,619	30,158	22.32	11.10
Crowley	1964	3,357	3,815	9,273	10,538	8.23	9.35
	69	5,811	5,283	18,897	17,097	13.41	12.19
	74	34,979	18,705	143,946	76,976	80.14	42.86
	78	70,439	35,043	282,889	140,737	157.60	78.75
Custer	1964	1,017	1,156	6,646	7,552	4.23	5.97
	69	1,976	1,796	16,067	14,606	7.94	9.50
	74	2,771	1,482	24,097	12,886	11.44	7.02
	78	4,838	2,402	43,492	21,637	19.85	9.90
El Paso	1964	6,658	7,566	13,719	15,590	5.25	7.63
	69	11,877	10,797	18,272	16,611	10.45	8.33
	74	12,380	6,620	22,227	11,886	13.12	6.65
	78	22,187	11,038	35,613	17,717	23.22	11.61
Fremont	1964	2,933	3,333	5,652	6,423	6.71	5.97
	69	4,000	3,636	12,861	11,692	9.16	7.22
	74	5,036	2,693	20,641	11,038	12.43	7.02
	78	8,306	4,132	24,720	12,298	20.35	10.15
Huerfano	1964	2,073	2,356	8,603	9,776	2.52	2.86
	69	3,654	3,240	16,656	15,142	5.04	4.58
	74	3,574	1,911	17,782	9,509	5.03	6.65
	78	6,534	3,251	27,000	13,433	9.48	4.71
Kiowa	1964	3,485	3,960	11,463	13,026	3.94	4.48
	69	9,791	8,901	23,763	21,603	9.75	8.86
	74	22,975	12,286	59,520	31,829	22.93	12.26
	78	18,060	8,985	49,361	24,557	18.01	9.00

Table A-17 (Con't)

County	Year	Total Sales for All Farms $1,000	Total Sales for All Farms 1966-1968 $1,000	Average Sales Per Farm $	Average Sales Per Farm 1966-1968 $	Average Sales Per Acre $	Average Sales Per Acre 1966-1968 $
Lake	1964	NA	NA	NA	NA	NA	NA
	69	NA	NA	NA	NA	NA	NA
	74	293	141	29,290	15,663	15.57	8.33
	78	NA	NA	NA	NA	NA	NA
Las Animas	1964	3,740	4,250	6,727	7,644	1.62	1.84
	69	6,833	6,212	13,974	12,704	2.96	2.69
	74	8,230	4,401	20,221	10,813	3.89	2.08
	78	16,458	8,188	34,869	17,347	7.63	3.81
Lincoln	1964	8,237	9,360	15,425	17,528	5.08	5.77
	69	12,946	11,769	26,971	24,519	8.27	7.52
	74	27,036	14,458	60,892	32,563	16.74	8.95
	78	46,767	23,267	98,456	48,982	29.11	14.52
Otero	1964	20,055	22,790	30,996	35,223	25.56	29.05
	69	41,624	37,840	72,013	65,466	77.94	70.85
	74	55,068	29,448	100,123	53,542	86.40	46.20
	78	70,726	35,186	122,789	61,088	92,67	46.31
Prowers	1964	13,009	14,783	19,046	21,643	12.62	14.34
	69	25,748	23,407	38,486	34,987	27.91	25.37
	74	75,301	40,268	121,846	65,158	73.76	39.44
	78	75,256	37,440	130,201	64,775	77.11	38.54
Pueblo	1964	7,718	8,870	10,102	11,480	5.78	6.57
	69	18,021	16,383	29,301	26,237	15.90	14.45
	74	31,404	16,794	54,145	28,955	25.55	13.66
	78	29,970	14,911	49,293	24,523	28.58	14.27
Teller	1964	313	356	5,305	6,028	2.65	3.01
	69	932	847	15,276	13,887	5.77	5.25
	74	722	386	16,801	8,984	6.55	3.50
	78	1,155	575	21,002	10,449	10.14	5.06
Basin	1964	92,653	105,287	13,030	14,807	6.38	7.25
	69	189,478	172,253	28,919	26,290	13.80	12.55
	74	367,416	196,479	60,982	32,611	26.10	14.39
	78	417,676	234,659	75,734	37,678	35.00	17.48
State	1964	612,175	695,653	20,544	23,345	16.00	18.18
	69	1,100,948	1,000,862	39,389	35,808	30.00	27.27
	74	1,970,236	1,053,602	77,261	41,316	54.88	29.35
	78	2,606,511	1,296,740	87,800	43,681	73.04	36.49
Percent of State	1964	15	15	63	63	40	40
	69	17	17	73	73	46	46
	74	19	19	79	79	48	48
	78	18	18	86	86	48	48

1/ Adjusted to value of dollar for 1966-68 average.
Source: Colorado Census of Agriculture: 1964, 1969, 1974, and 1978. Bureau of Census, Department of Commerce. 1981 Colorado Ag. Statistics.
NA - Not Available.

Table A-18 - Crop and Livestock Sales 1/
Arkansas River Basin, Colorado

County		Crops $1,000	Livestock $1,000	Total $1,000	% of Sales Crops	% of Sales Livestock
Baca	1964	5,011	4,041	9,054	55	45
	69	7,154	18,416	25,570	28	72
	74	24,472	20,042	44,514	55	45
	78	18,117	36,105	54,221	33	67
Bent	1964	2,043	4,414	6,461	32	68
	69	2,353	9,247	11,600	20	80
	74	6,380	15,356	21,765	29	71
	78	4,948	18,692	23,640	21	79
Chaffee	1964	117	837	956	12	88
	69	223	1,426	1,649	14	86
	74	329	1,515	1,844	18	82
	78	510	2,244	2,754	19	81
Cheyenne	1964	533	3,054	3,587	15	85
	69	2,557	4,979	7,536	34	66
	74	13,433	6,120	19,554	69	31
	78	10,368	9,999	20,368	51	49
Crowley	1964	1,056	2,301	3,357	31	69
	69	1,653	4,158	5,811	40	60
	74	4,738	30,241	34,979	14	86
	78	2,506	67,933	70,439	4	96
Custer	1964	91	922	1,017	9	91
	69	301	1,671	1,976	15	85
	74	411	2,358	2,771	15	85
	78	344	4,484	4,828	7	93
El Paso	1964	1,105	8,388	6,658	12	88
	69	1,590	10,212	11,877	13	87
	74	3,353	9,020	12,380	27	73
	78	5,231	16,957	22,187	24	76
Fremont	1964	397	2,514	2,933	14	86
	69	582	3,412	4,000	15	85
	74	1,084	3,946	5,036	22	78
	78	1,354	6,952	8,306	16	84
Huerfano	1964	64	1,996	2,073	3	97
	69	163	3,387	3,564	5	95
	74	375	3,187	3,574	11	89
	78	323	6,211	6,534	5	95
Kiowa	1964	875	2,609	3,485	25	75
	69	3,576	6,215	9,791	37	63
	74	16,367	6,608	22,975	71	29
	78	8,608	9,458	18,066	48	52

Table A-18 (Con't)

County		Crops $1,000	Livestock $1,000	Total $1,000	% of Sales Crops	% of Sales Livestock
Lake	1964	NA	NA	NA	NA	NA
	69	NA	NA	NA	NA	NA
	74	(6)	(287)	(263)	2	98
	78	(13)	NA	NA	NA	NA
Las Animas	1964	338	3,357	3,740	9	91
	69	493	6,320	6,833	7	93
	74	974	7,148	8,230	12	88
	78	703	15,755	16,458	4	96
Lincoln	1964	1,158	7,078	8,237	14	86
	69	2,425	10,521	12,946	19	81
	74	11,631	15,378	27,036	43	57
	78	6,757	40,010	46,767	16	84
Otero	1964	5,515	14,5 9	20,055	28	72
	69	5,227	36,395	41,624	13	87
	74	10,771	44,297	55,068	20	80
	78	11,429	59,037	75,256	23	77
Prowers	1964	4,767	8,240	13,009	37	63
	69	7,522	18,226	25,748	29	71
	74	25,347	49,954	75,301	34	66
	78	17,219	58,037	75,256	23	77
Pueblo	1964	2,713	4,991	7,718	35	65
	69	3,825	14,188	18,021	21	79
	74	8,372	23,023	31,404	27	73
	78	7,979	21,991	29,970	27	73
Teller	1964	9	219	313	4	96
	69	38	893	932	4	96
	74	216	722	722	30	70
	78	33	1,121	1,155	3	97
Basin*	1964	25,792	92,653	92,653	28	72
	69	32,160	189,478	189,478	17	83
	74	128,253	367,416	367,416	35	65
	78	96,429	375,247	471,676	20	80
State	1964	182,317	612,175	612,175	30	70
	69	217,833	1,100,948	1,100,948	20	80
	74	682,791	1,245,846	1,970,236	35	65
	78	574,778	1,971,748	2,606,571	24	76
Per Cent of State	1964	14	16	15		
	69	15	17	17		
	74	19	19	19		
	78	17	19	18		

1/ In terms of actual dollars.
NA: Data not available.
* Lake County not included in Basin Totals.
Source: Colorado Census of Agriculture: 1969, 1974.
U.S. Department of Commerce - Bureau of Census.

Baca and Prowers counties had the largest sales for crops, and Otero, Crowley, and Prowers counties had largest sales for both livestock and total sales. The smallest crops sales were in Chaffee, Custer, Huerfano, Teller and Lake counties. Livestock and total sales were lowest in Lake and Teller counties. A-51

Crop Production

Nine important crops raised in the Arkansas Basin were selected for comparison for the years 1964, 1969, 1974, and 1978: winter wheat, corn for grain, barley, sorghum grain, dry beans, sugar beets, oats, all hay, and corn silage, Table A-19.

During the period 1964 to 1974 there was a dramatic increase in winter wheat and corn grain. Corn silage production rose in the State in 1974, but dropped slightly in the Basin after a significant increase the preceding 10 years. Both crops increased significantly in 1978.

The most important crops raised in the basin and statewide were winter wheat, all hay, sorghum grain, corn grain, and corn silage. The Basin was the largest producer of sorghum grain in Colorado, producing about 90% of the State's crop in 1978.

Baca and Prowers counties together were responsible for over 70% of this crop in the basin and over 60% of the state production.

Of particular interest is the rising importance from 1964-1974 of the Arkansas Basin as a producer of winter wheat. The region raised only 14% of the state's crop in 1964 compared to 27% in 1969 and 29% in 1974. Production then decreased in the region to 28% of the state's production in 1978. Baca, Cheyenne, Kiowa, Lincoln, and Prowers counties were the important growers. Most of the winter wheat was grown on dry land acreage.

Hay is the one crop grown by every county in the Arkansas Basin. Despite the acreage losses and the production drop in 1974, and 1978, hay was the second most valuable crop over the decade. The Basin was responsible for about 20% of the State's hay during this period, and Prowers county was by far the largest producer in the region.

Corn for grain production rose dramatically from 1964 to 1974. While it increased in importance in the basin over the ten years, the region contributed only about 12% of the State's total crop. Baca County was the Basin's largest producer in 1974 but was replaced by Cheyenne County in 1978. About 16% of the State's corn silage was grown in the Arkansas Basin, with Baca and Otero Counties being the region's largest producers.

The Basin produced less than 10% of the State's oats, sugar beets, dry beans and barley.

Table A-19 - Crop Production
Arkansas River Basin, Colorado

County		Winter Wheat BU.	Corn Grain Bu.	Barley Bu.	Sorghum Grain	Sugar Beets Tons
Baca	1964	1,122,600	73,170	15,500	1,085,000	37,760
	69	1,928,900	1,879,600	74,480	2,968,300	48,300
	74	3,522,020	1,995,990	51,080	2,985,290	8,160
	78	3,619,100	684,300	21,750	4,632,140	0
Bent	1964	191,200	23,140	10,750	763,500	14,750
	69	450,000	284,800	15,000	1,249,000	8,400
	74	432,790	126,010	41,010	969,120	4,450
	78	183,850	135,900	27,440	904,500	6,150
Chaffee	1964	1,020	0	6,450	0	0
	69	1,110	0	2,250	0	0
	74	0	0	1,870	0	0
	78	0	0	0	0	0
Cheyenne	1964	400,000	19,500	3,600	117,400	0
	69	1,949,000	479,900	15,680	181,500	14,700
	74	3,557,880	436,820	19,540	163,940	31,370
	78	2,964,600	1,440,660	21,800	244,740	NA
Crowley	1964	31,850	83,450	1,500	184,000	3,480
	69	76,800	268,600	6,630	456,600	5,300
	74	239,800	512,520	3,510	249,060	3,160
	78	NA	340,490	NA	143,260	0
Custer	1964	5,600	4,500	1,620	750	0
	69	700	4,500	12,510	3,000	0
	74	NA	NA	NA	NA	0
	78	NA	NA	NA	NA	0
El Paso	1964	108,500	31,800	4,550	2,940	0
	69	225,800	145,450	12,000	24,000	0
	74	101,500	29,660	2,430	16,010	0
	78	86,740	28,460	2,320	50,580	0
Fremont	1964	15,650	15,790	3,360	1,000	0
	69	20,050	16,000	17,800	660	0
	74	NA	0	NA	NA	0
	78	12,220	21,880	NA	NA	0
Huerfano	1964	18,800	15,640	2,880	0	0
	69	48,650	4,500	8,320	2,680	0
	74	56,020	3,060	NA	0	0
	78	20,410	0	260	0	0
Kiowa	1964	207,600	0	400	352,900	0
	69	3,539,800	91,300	0	693,100	6,300
	74	4,541,200	231,320	NA	779,620	0
		2,817,500	36,720	1,040	866,020	0

Table A-19 (Con't)

County		Winter Wheat Bu.	Corn Grain Bu.	Barley Bu.	Sorghum Grain Bu.	Sugar Beets Tons
Lake	1964	0	0	0	0	0
	69	0	0	0	0	0
	74	0	0	0	0	0
	78	0	0	0	0	0
Las Animas	1964	50,200	14,580	10,620	8,280	2,440
	69	130,000	21,600	6,630	53,900	0
	74	187,360	12,400	8,870	0	0
	78	126,750	12,610	13,600	7,640	0
Lincoln	1964	680,700	14,300	9,900	146,500	0
	69	1,537,700	40,800	19,600	105,800	0
	74	3,718,930	14,780	26,100	108,270	0
	78	2,469,960	80,500	29,340	83,820	0
Otero	1964	114,000	410,350	45,340	225,000	45,640
	69	67,200	596,300	18,870	354,200	42,000
	74	143,860	1,041,880	28,720	195,080	39,080
	78	128,420	1,006,800	19,700	152,600	20,100
Prowers	1964	521,600	99,730	23,200	1,863,470	33,930
	69	1,768,500	161,500	114,810	3,358,960	43,400
	74	3,482,240	1,204,602	196,400	1,554,060	38,580
	78	2,648,270	636,650	212,710	1,864,000	27,800
Pueblo	1964	178,500	289,850	50,730	104,000	26,100
	69	289,700	534,300	66,500	251,700	11,000
	74	163,760	410,920	40,210	204,420	4,370
	78	63,540	571,650	12,710	249,700	NA
Teller	1964	550	0	0	0	0
	69	0	0	0	0	0
	74	0	0	0	0	0
	78	0	0	0	0	0
Basin Total	1964	3,648,370	1,095,800	191,400	4,854,740	164,100
	69	12,033,910	4,529,150	391,080	9,714,400	179,400
	74	20,147,390	6,041,860	419,730	7,224,860	129,180
	78	15,451,160	4,996,601	362,690	9,198,970	54,050
State Total	1964	26,257,000	12,350,000	9,060,000	6,738,000	2,783,000
	69	44,793,000	27,935,000	11,994,000	11,041,000	3,224,000
	74	70,089,500	50,167,220	9,718,360	7,743,310	2,175,030
	78	55,175,290	77,940,310	12,764,560	10,214,910	1,529,330
Per Cent of State	1964	14	9	2	72	6
	69	27	16	3	88	6
	74	29	12	4	93	6
	78	28	6	3	90	4

Table A-19 (Con't)

County		Dry Beans Cwt.	Oats Bu.	All Hay Bu.	Corn Silage Tons
Baca	1964	900	5,440	9,040	10,500
	69	125	0	22,550	119,430
	74	1,940	0	22,180	81,600
	78	0	0	19,330	150,400
Bent	1964	300	11,880	42,880	4,000
	69	1,900	27,900	83,350	29,400
	74	0	19,740	71,060	25,500
	78		18,840	78,000	14,700
Chaffee	1964	0	8,820	24,670	910
	69	0	9,500	17,270	0
	74	0	4,100	14,940	0
	78	0	NA	12,380	0
Cheyenne	1964	0	240	5,250	5,000
	69	3,950	0	15,750	42,000
	74	0	NA	11,800	13,200
	78	0	NA	18,760	37,600
Crowley	1964	4,400	600	23,510	8,400
	69	9,020	5,000	43,850	57,270
	74	14,380	0	39,790	80,000
	78	11,840	0	34,320	54,500
Custer	1964	0	39,600	19,720	780
	69	0	25,140	52,410	0
	74	0	4,200	15,150	0
	78	0	0	15,970	0
El Paso	1964	8,170	7,370	18,970	30,600
	69	12,400	61,900	40,200	70,030
	74	4,040	13,260	30,860	26,000
	78	3,950	5,210	23,620	28,200
Fremont	1964	260	5,550	21,340	10,400
	69	0	10,000	24,820	6,620
	74	0	2,300	13,490	11,400
	78	0	3,380	11,520	0
Huerfano	1964	0	9,610	37,000	3,120
	69	125	26,300	28,920	2,130
	74	0	1,340	20,830	0
	78	0	3,040	14,280	0
Kiowa	1964	0	0	14,890	1,800
	69	0	0	17,380	18,050
	74	0	NA	6,860	6,600
	78	0	NA	15,940	1,700

Table A-19 (Con't)

County		Dry Beans Cwt.	Oats Bu.	All Hay Tons	Corn Silage Tons
Lake	1964	0	0	5,990	0
	69	0	0	3,000	0
	74	0	0	700	0
	78	0	0	580	0
Las Animas	1964	0	17,000	25,670	5,600
	69	820	24,500	35,210	21,700
	74	0	9,100	14,400	4,800
	78	0	19,410	23,590	0
Lincoln	1964	3,600	100	15,510	2,700
	69	1,040	10,000	23,430	14,800
	74	1,100	NA	16,280	13,000
	78	610	NA	20,090	18,200
Otero	1964	15,600	78,450	63,260	83,200
	69	7,800	41,800	53,920	94,500
	74	9,470	22,850	72,780	147,500
	78	5,990	8,250	88,510	190,000
Prowers	1964	500	15,370	103,380	7,200
	69	0	9,050	119,150	69,750
	74	NA	4,090	179,630	95,200
	78	NA	13,850	197,240	123,500
Pueblo	1964	65,940	44,700	38,200	20,800
	69	73,585	30,180	63,120	47,200
	74	52,500	5,860	46,463	77,400
	78	103,800	2,680	43,720	127,500
Teller	1964	38,360	2,560	2,000	0
	69	0	0	4,430	0
	74	0	0	7,800	0
	78	0	0	1,620	0
Basin Total	1964	99,670	247,290	471,280	195,010
	69	110,765	281,270	648,760	592,880
	74	136,738	86,850	585,030	582,200
	78	50,100	74.650	619,480	746,300
State Total	1964	1,547,000	3,081,000	2,827,000	2,492,000
	69	1,909,000	3,906,000	3,321,000	3,927,000
	74	1,542,790	1,221,540	2,794,760	3,816,553
	78	1,480,890	1,880,630	3,047,600	4,673,798
Per Cent of State	1964	6	8	17	8
	69	6	7	20	15
	74	9	7	21	15
	78	3	4	20	16

NA: Data not available.
Sources: U.S. Department of Commerce, Bureau of Census, Census of Agriculture.
* Colorado Agriculture Statistics

Livestock Production

All Cattle and Calves - Colorado ranked thirteenth, eleventh, twelfth, and sixteenth in production for the Census years 1964, 1969, 1974, and 1978, respectively. While none of the counties in the Arkansas River Basin were among the top cattle producers in the state, the region as a whole supplied about one quarter of the state's cattle and calves, (Table A-20). Within the Basin, Prowers, Otero, Baca and Lincoln counties were the top producers. Over the 1964-1974 period, the Basin experienced an increased rate of cattle production, with dramatic increases in Crowley and Prowers counties (greater than 100%). In contrast, cattle have decreased steadily in Chaffee, Fremont, and El Paso counties.

Calves and Heifers that had Calved - During the Census years 1964, 1969, 1974, and 1978, the Arkansas River Basin produced slightly more than 25% of the state's calves and heifers that had calved. Over the 1964-1974 period, the Basin increased their production of this category of cattle, though the increase was lower than for the All Cattle and Calves category. A slight drop occurred in the 1978 census. The largest producers of calves and heifers were Baca and Las Animas counties. Otero was unusual in experiencing a 40% decrease in production from 1964 to 1969 followed by a 29% increase in production from 1969 to 1974, and a 16% reduction in 1978.

Milk Cows - The Basin experienced a downward trend in milk cow production during the ten years from 1964 to 1974 but reversed itself in 1978. Production in Bent, Cheyenne, Custer, El Paso, Huerfano, Lincoln, Otero and Prowers counties decreased from 1964-1978. During this time, the Basin produced about 15% of the state's dairy cattle, and El Paso, Fremont and Pueblo counties accounted for 65% of the regions production.

Hogs and Pigs - The Basin increased its production of hogs and pigs in the Census years 1964, 1969, 1974, and 1978, showing a 118% increase. The counties with the greatest increased production were Baca, Bent, Crowley, El Paso, and Lincoln. Custer and Chaffee showed dramatic decreases in production, but neither county had large numbers of these animals to begin with. The Basin produced about 20% of the state's hogs and pigs during the Census years, and Bent, Crowley, EL Paso, Lincoln, and Otero, counties provided well over 65% of the Basin's porkers.

Sheep and Lambs - The Basin has not been an important producer of sheep and lambs, producing only 13%, 7%, 2%, and 3%, of the State's total in 1964, 1969, 1974, and 1978, respectively. From 1964 to 1978 production decreased 85%. Every county in the Basin reduced its sheep and lamb production during this period, and only Bent, Otero and Prowers counties raised significant numbers of these animals.

Chickens Three Months and Older - During 1964 to 1978, chicken production in the Basin declined 85%, with all counties showing reduced inventories. The Basin produced 24% of the state's chickens in 1964 compared to 12% in 1969 and 3% in 1974 and 1% in 1978. The top producing counties in the region were El Paso, and Fremont.

Horses and Ponies - Horses and ponies declined slightly in the Basin from 1969 to 1978. The Basin produced about 17% of the state's horses and ponies, and the counties with the greatest productivity were El Paso, Las Animas, and Pueblo.

Table A-20 - Livestock Production
Arkansas River Basin, Colorado

County		Cattle and Calves	Calves and Heifers that had Calved	Milk Cows	Hogs and Pigs	Sheep and Lambs	Chickens 3 Months or Older	Horses and Ponies
Baca	1964	42,065	17,567	447	1,897	3,619	9,541	NA
	69	92,970	25,684	190	3,389	6,280	4,568	975
	74	78,988	31,959	158	2,494	119	3,166	787
	78	73,987	25,117	154	5,214	399	3,409	823
Bent	1964	39,160	17,169	420	4,145	47,824	24,148	NA
	69	48,988	21,312	234	4,891	25,288	3,852	622
	74	53,184	22,601	179	7,461	5,057	1,402	469
	78	53,098	16,785	139	8,222	5,168	1,220	594
Chaffee	1964	9,390	5,287	490	172	2,337	10,179	NA
	69	8,602	4,519	535	253	2,280	7,814	507
	74	7,209	3,795	553	76	245	10,723	361
	78	8,433	4,515	547	151	126	NA	NA
Cheyenne	1964	39,130	19,664	260	1,176	3,207	4,901	NA
	69	43,719	17,968	96	2,133	2,355	2,263	466
	74	42,549	23,137	180	2,481	42	2,026	355
	78	37,252	15,312	84	2,448	NA	1,074	379
Crowley	1964	23,818	10,445	614	2,769	1,618	12,932	NA
	69	29,917	12,301	325	4,936	6,019	9,278	438
	74	53,204	11,783	561	3,979	189	3,828	361
	78	71,539	8,390	472	10,699	NA	3,723	346
Custer	1964	13,283	7,178	406	112	1,172	1,955	NA
	69	15,923	7,205	139	102	499	1,001	473
	74	14,628	7,971	90	7	26	460	444
	78	13,266	5,620	60	NA	NA	877	460
El Paso	1964	54,996	20,073	4,334	1,961	6,000	71,537	NA
	69	54,671	24,277	3,541	5,412	1,540	16,469	1,863
	74	51,906	27,072	2,512	14,814	645	13,533	1,211
	78	41,503	21,668	2,743	16,572	375	10,164	1,751
Fremont	1964	22,818	11,843	2,121	1,731	635	34,750	NA
	69	21,312	11,488	2,096	1,853	284	24,728	578
	74	17,171	9,782	1,701	1,486	353	13,636	408
	78	14,637	8,001	1,922	3,386	316	7,597	936
Huerfano	1964	26,595	14,562	728	639	5,040	13,153	NA
	69	30,593	13,249	572	250	5,040	2,332	602
	74	30,820	16,009	322	539	436	1,293	495
	78	28,293	12,897	568	339	556	1,285	483
Kiowa	1964	31,534	14,339	131	2,109	2,567	6,153	NA
	69	52,435	18,531	73	2,179	7,674	3,031	712
	74	42,155	20,146	31	470	821	881	432
	78	35,974	13,074	84	1,941	1,292	1,186	437

Table A-20 (Con't)

County		Cattle and Calves	Calves and Heifers that had Calved	Milk Cows	Hogs and Pigs	Sheep and Lambs	Chickens 3 Months or Older	Horses and Ponies
Lake	1964	NA	NA	NA	NA	NA	NA	NA
	69	NA	NA	NA	NA	NA	NA	NA
	74	(2,311)	(229)	(2)	(0)	(50)	(5)	(64)
	78	NA	(138)	NA	(0)	NA	NA	(85)
Las Animas	1964	61,160	35,584	491	676	4,178	16,279	NA
	69	67,578	34,049	377	950	1,942	3,592	1,505
	74	58,915	29,295	460	471	358	2,608	909
	78	66,530	30,500	659	528	497	2,536	1,242
Lincoln	1964	57,623	26.537	535	1,856	11,407	10,229	NA
	69	69,963	26,795	232	3,890	6,278	2,876	709
	74	73,904	34,412	150	5,068	2,896	3,388	507
	78	79,857	23,473	119	6,796	199	1,921	554
Otero	1964	62.163	19,547	822	7,306	26,695	43,922	NA
	69	70,736	11,774	1,113	9,805	9,405	72,821	682
	74	70,329	15,172	644	8,215	5,085	9,208	973
	78	81,506	12,616	752	9,182	7,912	1,886	886
Prowers	1964	54,141	20,455	541	5,447	77.812	24,369	NA
	69	92,265	21,468	144	8,753	24,184	10,213	1,120
	74	109,870	26,531	105	8,272	3,261	3,406	873
	78	94,804	21,418	147	5,638	9,907	2,172	761
Pueblo	1964	47,764	22,411	1,790	3,653	1,873	17,231	NA
	69	53,640	18,824	1,897	4,116	744	3,937	1,736
	74	79,361	21,547	2,256	3,048	742	3,845	898
	78	49,334	19,234	2,721	6,489	1,443	3,490	1,820
Teller	1964	3,894	2,199	24	20	0	1,287	NA
	69	4,848	2,382	18	0	15	497	617
	74	3,723	3,723	11	60	0	208	299
	78	3,178	1,788	14	126	NA	372	277
Basin Totals*	1964	589,534	273,860	14,164	35,669	195,984	302,566	NA
	69	758,160	271,826	11,582	52,912	99,827	170,272	13,605
	74	787,916	303,301	9,913	48,941	20,294	73,611	9,782
	78	753,191	240,470	11,185	77,731	28,190	42,872	12,230
State Totals*	1964	2,499,250	949,735	92,731	169,755	1,482,050	1,279,550	NA
	69	3,001,895	955,929	75,288	237,996	1,455,872	1,430,209	61,260
	74	3,087,884	1,096,597	71,353	291,342	985,019	2,253,086	45,227
	78	3,183,396	924,803	78,242	391,838	807,299	3,337,824	70,008
Per Cent of State	1964	24	29	15	21	13	24	NA
	69	25	28	15	22	7	12	22
	74	26	28	14	20	2	3	22
	78	24	26	14	20	3	1	17

* Lake County not included in Basin totals.
NA Data not available.
Source: Colorado Census of Agriculture: 1969, 1974, 1978 and Dept. of Commerce, Bureau of Census.

UNIQUE AREAS

Archeological Sites

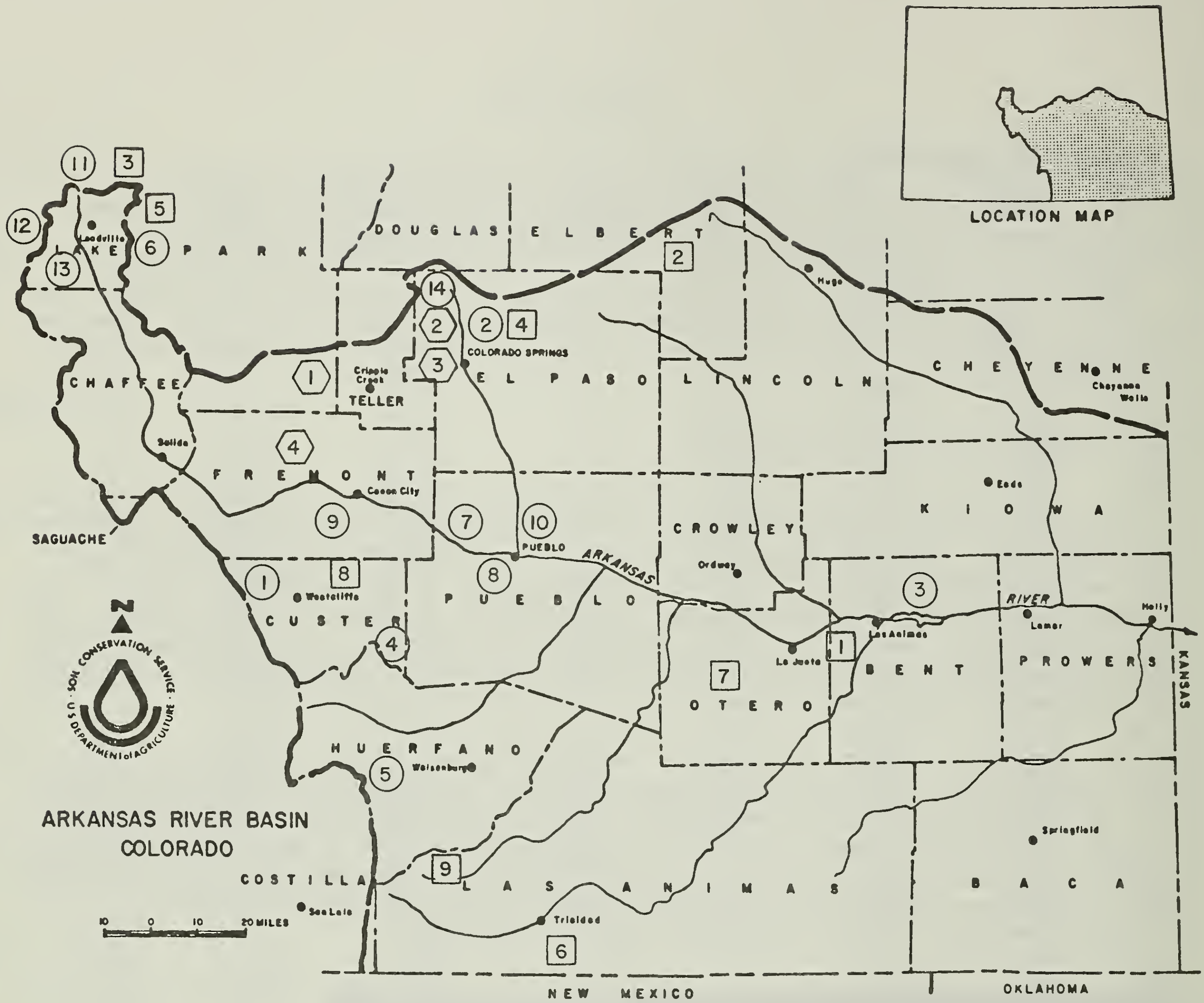
Archeological areas noted in figure A-8 are those areas that indicate evidence of human life and activities in a given area prior to the development of written history. The Garden of the Gods area contains excellent evidence of early human activity in the Arkansas River Basin. The Ute Indians previously hunted game and gathered food in this area. Hunting parties lived throughout the area in the spring and summer months during prehistoric times.

Cultural or Historical Features

The Arkansas River Basin contains many historical sites and areas. The Leadville area and the Pike Peaks region attracts several thousand tourists each year. THe historic mining districts of Leadville and Silvercliff are two towns that delight historical enthusiasts. Vast amounts of gold, silver, and other precious metals were previously mined in these areas. The old Sante Fe Trail, located in southeastern Colorado, is a testimony to the western migration of early pioneers and the early transportation of freight. This trail traversed southern Kansas, Colorado and New Mexico.

Bent's Old Fort, presently a national historic site, served as a fur trading post, a way station, and a military staging area. The fossil beds of Florrissant provide the curious visitor with the fossilized impressions of insects and leaves preserved by volcanic ashfalls in an ancient lakebed 34 to 35 million years old. The Pike and San Isabel National Forests afford the outdoor enthusiast with ample opportunities in camping, hiking, cross-country skiing, and other outdoor activity.

Historical Site - Bents Old Fort



ARCHEOLOGICAL VALUES

1. Florissant Fossil Beds Monument
2. Garden of the Gods
3. Garden Park Fossil Area
4. Indian Springs Trace Fossil Site

HISTORICAL VALUE

1. Bents Old Fort
2. Big Sandy Creek Area
3. Climax Molybdemum Mining
4. Garden of the Gods
5. Leadville
6. Raton Mesa
7. Santa Fe Trail
8. Silver Cliff
9. Spanish Peaks

MAJOR TOURIST AREAS

1. De Weese Reservoir
2. Garden of the Gods
3. John Martin Reservoir
4. Lake Isabel
5. Lathrop State Park
6. Leadville Historic
7. Pike National Forest
8. Pueblo Dam
9. Royal Gorge
10. San Isabel National Forest--Forest Supervisor
11. Ski Cooper Winter Sports Area
12. Turquoise Lake
13. Twin Lakes Recreational Area
14. United States Air Force Academy

Figure A-8 OUTDOOR RECREATION AND TOURIST AREAS

APPENDIX - B SUPPLEMENTAL DATA

Table of Contents

List of Tables

APPENDIX B - SUPPLEMENTAL DATA

IRRIGATION SYSTEM NEEDS

An initial segment of this study involved inventories of 114 canal systems to identify needed improvements. Table B-1 lists these improvements for each canal system and related on-farm systems. A summary of this table is shown in table I-1. Location of each system is shown on plate Irrigation Systems Inventoried in chapter I.

Table B-1 - Irrigation System Needs 1/
Arkansas River Basin Study

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
10-1	Chilcotte	4.0	3.4	1.0	0	3.0	1.4	7.0	70.0	70.0	0	1400.0
10-2	Fountain Mutual	18.0	14.0	2.2	0	33.0	2.0	15.0	150.0	150.0	0	3000.0
10-3	Lock	0	1.6	0.2	1.0	2.0	5.0	0.5	25.0	110.0	0	450.0
11-1	Hoosier	7.0	1.5	0	1.0	3.0	5.0	5.0	40.0	100.0	0	700.0
11-2	Dry Field	0	0	2.5	0	0	0	2.5	5.0	0	0	160.0
11-3	Riverside Allen	8.0	0	0	1.0	3.0	1.0	1.0	10.0	0	0	300.0
11-4	Link-Irving	0	0	0	0	0	0	1.0	5.0	0	0	220.0
11-5	Trout Creek Helena	0	0	0	0	1.0	0	5.0	30.0	100.0	0	800.0
11-6	New Salida	0	0.75	0	1.0	2.0	4.0	3.5	75.0	0	0	1000.0
11-7	Frantz	0	0	0	0	12.0	0	0	0	0	0	600.0
11-8	Younger No. 1	0	0	0	1.0	10.0	0	0	6.0	0	0	250.0
11-9	McPherson-Burnett	0	0	0	0	4.0	0	0	4.0	50.0	0	100.0
11-10	Burnett	0	0	0	0	0	0	0	0	0	0	227.0
11-11	Williams-Hamm	0	3.0	0	0	2.0	0	0	75.0	0	0	620.0
11-12	Poncha Springs	0	0	2.5	0	4.0	0	0	0	0	0	80.0
11-13	Tenassee	0	2.5	0	1.0	22.0	0	10.0	50.0	100.0	0	300.0
11-14	Murray	8.0	0	0	0	0	0	0	0	100.0	0	435.0
11-15	McKenna	3.0	3.0	0	0	6.0	1.5	1.5	8.0	100.0	0	220.0

Table B-1 (Con't)

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
11-16	Cameron	12.0	0	0	0	2.0	0	10.0	20.0	0	0	600.0
11-17	Bowen	0	0.1	0	1.0	5.0	0	0	50.0	0	0	2000.0
11-18	Wells:Starr	0	3.0	0	1.0	2.0	4.0	3.0	4.0	0	0	200.0
11-19	Sunny-Side Park	0	1.5	0	1.0	1.0	0	0	30.0	100.0	0	600.0
11-20	Willow Dale	0	0	0	0	0	0	0	10.0	0	0	800.0
11-21	Missouri Park	0	6.0	0	0	20.0	7.0	5.0	50.0	150.0	0	1940.0
11-22	North Fork	0	0	0	0	0	3.0	2.0	25.0	80.0	0	2600.0
11-23	Newby-Bowring	0	4.0	0	1.0	0	5.0	10.0	30.0	500.0	0	660.0
11-24	Hogue	0	3.0	0	0	0	2.0	2.5	12.0	50.0	0	166.0
11-25	Hills:Sprague	4.5	0	0	1.0	2.0	0	2.5	6.0	80.0	0	280.0
11-26	Del Monte	0	3.0	0	1.0	1.0	0	2.0	5.0	0	0	185.0
11-27	Pioneer	0	0	1.5	0	0	2.0	3.0	40.0	100.0	0	700.0
11-28	Wolf:Neerland	0	2.0	0	1.0	1.0	1.0	1.0	0	0	0	250.0
11-29	Cottonwood	4.0	2.5	1.5	0	1.0	5.0	10.0	40.0	150.0	0	480.0
11-30	Low Land	0.7	0	2.0	0	3.0	0	11.5	36.0	0	0	430.0
12-1	Garden Park	0	1.6	0	0	6.0	2.0	1.0	15.0	12.0	0	180.0
12-2	Canon City Hyd.	0	5.25	0	1.0	1.0	10.0	5.0	100.0	400.0	0	4000.0
12-3	Grandview	0	3.9	0.1	0	11.0	2.0	1.5	6.0	50.0	0	1296.0
12-4	Fruit Land	0	4.0	0	0	200.0	5.0	5.0	100.0	80.0	0	531.0

Table B-1 (Con't)

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
12-5	Harrington	0	0	3.5	1.0	3.0	0	4.0	10.0	120.0	0	200.0
12-6	Cascade	0	0	2.0	0	10.0	0	1.0	10.0	100.0	0	500.0
12-7	Pump	0	0	3.5	0	100.0	0	5.0	100.0	0	0	197.0
12-8	Canon City Oil Creek	0	3.9	0.1	1.0	10.0	15.0	10.0	75.0	100.0	0	800.0
12-9	South Canon	0	3.0	0	0	102.0	20.0	2.0	50.0	50.0	0	575.0
12-10	Fremont	0	0.4	0	1.0	0	15.0	15.0	200.0	400.0	0	800.0
12-11	Crooked	0	2.0	3.5	0	30.0	5.0	5.0	100.0	0	0	500.0
12-12	Canon Heights	0	4.0	9.0	0	0	0	4.0	50.0	150.0	0	813.0
12-13	Lester Atterberry	0	0	1.0	1.0	2.0	0	3.5	16.0	0	0	220.0
12-14	Union Ditch	0	3.9	0	0	10.0	10.0	10.0	50.0	600.0	0	1200.0
12-15	Beaver Park	0	5.0	47.0	1.0	1.0	0	50.0	200.0	0	0	3482.0
12-16	Pleasant	0	0	0	1.0	0	0	0	0	0	0	250.0
12-17	Baker Potter	3.0	0	3.0	0	6.0	0	6.0	12.0	0	0	310.0
13-1	Reise Lock	0	4.0	0	0	0	6.0	0	0	100.0	0	1000.0
13-2	E.L.R. Shield Johnson	2.5	0	0	0	0	0	0	0	0	0	500.0
13-3	Koch	0	0	0	0	0	0	0	2.0	0	0	400.0
13-4	W.A. Bell No. 1	0	0.5	0	0	1.0	0	0	0	0	0	320.0
13-5	De Weese Dye	0	1.5	1.5	0	125.0	3.5	3.5	200.0	100.0	0	1100.0
13-6	ULA	0	0	0	0	0	0	0	0	0	0	700.0

Table B-1 (Con't)

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
14-1	Bessemer	0	8.0	0	0	70.0	40.0	60.0	100.0	1000.0	500.0	20000.0
14-2	Oxford Farmers	0	4.5	0	1.0	2.0	30.0	50.0	50.0	600.0	350.0	6000.0
14-3	West Pueblo Enlarg.	0	0	0	0	0	0	0	0	0	0	235.0
14-4	Collier	0	0	0	0	0	0	0	0	0	75.0	1062.0
14-5	Rocky Ford Highline	0	25.0	0	0	355.0	100.0	250.0	0	12000.0	2400.0	24000.0
14-6	Colorado Canal	0	10.0	0	0	1.0	50.0	160.0	750.0	4900.0	1000.0	49000.0
14-7	Lake Henry	0	9.0	0	0	0	15.0	20.0	100.0	4500.0	300.0	9017.0
15-1	Bryson	0	1.0	0	0	1.0	0	0	0	0	0	340.0
15-2	Pioneer	0	0.25	0	0	0	0.1	0.5	0	0	0	210.0
16-1	Spanish Peaks	0	4.0	0	1.0	10.0	4.0	3.0	0	0	0	400.0
16-2	Garcia No. 1	0	3.0	0	1.0	16.0	3.0	3.0	40.0	200.0	0	300.0
16-3	Holita	0	0.4	0.6	0	5.0	4.0	2.5	0	200.0	0	650.0
16-4	Romero	0	0	1.5	0	0	0	1.5	18.0	0	20.0	145.0
16-5	Gomez	1.0	0	3.0	0	0	3.0	1.5	0	100.0	0	176.0
16-6	Butte	0	3.0	0	1.0	0	2.5	0	0	200.0	0	250.0
16-7	Palmer	0	3.0	0	1.0	1.0	6.0	0	0	250.0	0	500.0
16-8	Canal No. 1	0	0	5.0	1.0	1.0	0	10.0	0	250.0	0	500.0

Table B-1 (Con't)

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
16-9	Walsenburg	0	0	0	0	0	10.0	0	50.0	5000.0	0	800.0
16-10	Mexican	0	0	3.0	1.0	1.0	0	4.0	0	100.0	0	400.0
16-11	Welton	0	0	0	1.0	6.0	10.0	10.0	0	0	0	4000.0
16-12	Huerfano	0	0	0	0	0	20.0	20.0	200.0	2900.0	0	5800.0
17-1	Otero	0	15.0	0	1.0	5.0	20.0	20.0	255.0	2665.0	100.0	6661.0
17-2	Fort Lyon	0	50.0	0	0	303.0	500.0	500.0	2000.0	46500.0	18000.0	93000.0
17-3	Holbrook Lake	0	16.25	0	0	315.0	30.0	35.0	300.0	800.0	1000.0	16000.0
17-4	Rocky Ford	0	2.25	0	1.0	24.0	30.0	30.0	125.0	4000.0	500.0	8000.0
17-5	Catlin	0	0.5	0	0	1.0	20.0	25.0	150.0	2100.0	1250.0	18886.0
18-1	Jose Maxie Vigil	0	2.0	0	1.0	12.0	5.0	0	15.0	160.0	0	210.0
18-2	South Side Vigil	0	1.75	0	0	0	3.0	2.0	0	186.0	0	186.0
18-3	North Side Vigil	0	0	1.25	0	0	0	5.0	0	120.0	0	120.0
18-4	Borrego	0	0	0	0	10.0	0	4.0	10.0	0	0	1000.0
18-5	Antonio Sias	4.0	0	0	0	1.0	0	0	2.0	200.0	0	200.0
18-6	Jose Ramon Gonzolas	0	1.0	0	1.0	8.0	0.75	0	0	0	0	57.0
18-7	Lucero	0	1.7	0	1.0	3.0	0	3.5	24.0	175.0	0	225.0
18-8	Maurico Apadaca	0	2.0	0	1.0	4.0	0	0.75	0	125.0	0	125.0

Table B-1 (Con't)

REACH/SYSTEM		CANAL NEEDS					ON-FARM NEEDS					
No.	Name	Canal Cleaning Mi.	Canal Lining Mi.	Pipeline Mi.	Diversion Structure No.	Water Control Structure No.	On-Farm Lining Mi.	On-Farm Pipe Mi.	On-Farm W.C.S. No.	Land Leveling Ac.	Drainage Ac.	Irrigation Water Management Ac.
18-9	Felix Cruz	0	2.1	0	1.0	10.0	1.3	1.0	0	150.0	0	150.0
19-10	Gonzales	0	5.0	0	1.0	29.0	4.0	3.0	25.0	338.0	0	338.0
18-11	Antonio Pias	1.0	1.0	0	1.0	6.0	0.75	0	2.0	80.0	0	80.0
19-1	Model Res.	1.5	23.0	0	1.0	1.0	10.0	10.0	100.0	5000.0	0	6000.0
19-2	Pickett Wire	0	15.0	0	0	13.0	40.0	30.0	26.0	1200.0	0	2428.0
19-3	TiJeras	0	2.5	0	0	3.0	12.0	0	75.0	75.0	0	100.0
19-4	El Mora	0	0	1.4	0	2.0	0	9.5	0	75.0	0	300.0
19-5	Antonio Lopez	3.0	0	0	1.0	21.0	1.0	0	30.0	100.0	0	210.0
19-6	Trinchera	0	4.0	0	0	5.0	10.0	10.0	150.0	500.0	0	1000.0
19-7	Chilili	0	7.0	0	1.0	1.0	10.0	10.0	40.0	100.0	0	300.0
19-8	Baca	0	3.0	0	0	6.0	7.0	6.0	55.0	150.0	0	650.0
19-9	John Flood	0	5.0	0	0	1.0	30.0	30.0	125.0	200.0	0	2600.0
19-10	Hoehne	0	2.5	0	0	1.0	15.0	10.0	120.0	700.0	0	1200.0
19-11	Nine Mile	0	9.0	0	0	13.0	15.0	10.0	75.0	200.0	0	1440.0
19-12	Enlarged South Side	0	22.0	0	0	60.0	35.0	30.0	200.0	3200.0	0	6400.0
19-13	Juan Vasquez	1.0	3.0	0	0	1.0	0	1.0	10.0	60.0	0	600.0
19-14	Louis Torres	0	2.0	2.0	1.0	15.0	10.0	10.0	25.0	100.0	0	400.0
10-15	Highland	0	5.5	0	1.0	31.0	10.0	15.0	70.0	1500.0	1500.0	3000.0
67-1	Buffalo	0	1.0	0	0	0	40.0	62.0	100.0	600.0	0	6000.0
67-2	Amity	0	2.0	0	0	2.0	200.0	205.0	1500.0	8700.0	0	34683.0
67-3	Fort Bent	0	1.5	0	0	3.0	30.0	37.0	125.0	3250.0	1300.0	6500.0
67-4	Hyde	0	0	0	1.0	8.0	2.0	3.0	0	400.0	300.0	1000.0
67-5	Manvel	0	4.0	0	1.0	16.0	24.0	30.0	50.0	3000.0	0	5000.0
67-6	Lamar	0	8.0	0	1.0	8.0	38.0	50.0	100.0	3150.0	900.0	9000.0

1/ Data for 114 Canal Systems Inventoried

ALTERNATIVES

The following tables are supplementary to Tables II-2, II-3, and II-4 from Chapter 2. They reflect benefit cost information, and certain characteristics and effects of Alternative Plans for individual systems in the Basin.

Table B-2 - Plan To Maximize Net Farm Income (Plan A)
Arkansas River Basin, Colorado

	BENEFIT-COST						OTHER CHARACTERISTIC			
System	Map No.	Level of 2/ Improvement	Acres Served Ac.	Install Cost $	Avg Ann 3/ Cost $	Avg Ann 3/ Benefit $	Net Benefit $	System Irr 1/ Eff. %	Salinity Reduction Tons	Prime Lands With Full Water Ac.
Fountain Mutural	10-02	4	3,000	90,914	9,170	12,555	3,385	53/55	360	961
Bowen	11-17	3	2,000	224,665	24,097	20,380	-3,717	55/35	37	0
North Fork	11-22	4	2,600	43,361	4,347	6,860	2,513	53/33	20	0
Canon City Hyde	12-02	4	3,350	1,642,347	178,816	224,915	46,099	63/37	36	1,659
Grandview	12-03	4	1,038	38,331	3,910	57,617	53,707	63/43	53	681
Harrington	12-05	4	180	198,858	21,518	18,248	-3,270	53/35	6	15
Cascade	12-06	4	300	44,081	4,483	4,404	- 79	53/34	31	45
Canon City Oil	12-08	4	800	1,592,174	173,684	166,296	-7,388	63/28	5	800
Lester Atterberry	12-13	4	187	178,461	19,436	20,290	854	53/35	3	69
Beaver Park	12-15	4	2,509	377,699	39,670	50,824	11,154	53/34	277	678
Pleasant Valley	12-16	1	250	1,473,226	161,540	163,301	1,761	70/33	66	0
Reiser Lock	13-01	4	1,000	1,965	171	581	410	53/33	8	0
Bessemer	14-01	4	13,600	463,740	46,723	479,439	432,716	53/33	4,153	3,000
Oxford Farmers	14-02	4	5,954	1,631,605	177,552	248,995	71,443	53/33	1,343	3,314
West Pueblo Enlarge	14-03	1	235	1,847	160	9,644	9,484	70/43	86	86
Collier	14-04	4	876	1,965	171	5,190	5,019	53/33	47	0
Colorado Canal	14-06	4	35,525	1,661,080	168,309	633,902	465,593	53/33	1,523	0
Lake Henry	14-07	4	6,131	844,950	85,925	101,724	15,799	53/33	166	0

Table B-2 (Con't)

			BENEFIT-COST				OTHER CHARACTERISTIC			
System	Map No.	Level of 2/ Improvement	Acres Served Ac.	Install Cost $	Avg Ann 3/ Cost $	Avg Ann 3/ Benefit $	Net Benefit $	System Irr 1/ Eff. %	Salinity Reduction Tons	Prime Lands With Full Water Ac.
Palmer	16-07	4	500	201,543	21,783	17,981	- 3,802	53/33	8	0
Otero	17-01	4	5,595	2,201,455	235,685	185,606	-50,079	53/33	531	0
Fort Lyon	17-02	4	77,376	10,824,530	1,101,853	1,182,058	80,205	53/33	16,073	12,247
Holbrook	17-03	4	9,741	2,389,440	243,356	217,227	-26,129	53/34	3,245	0
Rocky Ford	17-04	4	5,600	2,276,911	243,383	596,898	353,515	53/37	3,002	3,482
Catlin	17-05	4	12,750	2,050,412	208,675	792,517	583,842	53/36	7,366	7,650
Lucero	18-07	4	225	231,123	24,810	18,181	- 6,629	53/31	5	0
Highland	19-15	4	1,905	527,668	54,988	53,642	- 1,346	53/34	313	83
Buffalo	67-01	4	3,750	214,840	21,744	149,023	127,279	53/36	2,004	1,670
Amity	67-02	4	25,145	3,047,846	309,992	346,252	36,260	53/33	5,250	1,651
Fort Bent	67-03	4	4,790	671,506	68,333	58,567	- 9,766	53/33	1,175	2,351
Hyde	67-04	4	718	247,066	26,413	28,028	1,615	53/33	289	388
Manvil	67-05	4	3,000	2,068,490	222,165	216,497	- 5,668	53/33	341	0
Lamar	67-06	4	5,963	2,136,086	228,943	270,564	41,621	53/33	1,875	2,939
			236,593	39,600,185	4,131,805	6,358,206	2,226,401	53/34	49,697	43,769

1/ Conveyance eff/on-farm efficiency.
2/ Level of Improvement 1-High, 2-Med High, 3-Med Low, 4-Low, BC Ratio 0.75 or Greater.
3/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits. Average annual costs include OM&R.

Table B-3 - Plan of Maximum Economically Feasible Improvements (Plan B)
Arkansas River Basin, Colorado

	BENEFIT-COST						OTHER CHARACTERISTIC			
System	Map No.	Level of 2/ Improvement	Acres Served Ac.	Install Cost $	Avg Ann 3/ Cost $	Avg Ann 3/ Benefit $	Net Benefit $	System Irr 1/ Eff. %	Salinity Reduction Tons	Prime Lands With Full Water Ac.
Fountain Mutual	10-02	4	3,000	90,914	9,170	12,555	3,385	53/55	360	961
Bowen	11-17	3	2,000	224,665	24,097	20,380	- 3,717	55/35	37	0
North Fork	11-22	4	2,600	43,361	4,347	6,860	2,513	53/33	20	0
Canon City Hydraulic	12-02	3	3,350	2,136,463	228,526	228,552	26	65/38	147	1,785
Grandview	12-03	2	1,107	527,223	53,370	59,224	5,854	70/50	190	851
Harrington	12-05	4	180	198,858	21,518	18,248	- 3,270	53/35	6	15
Cascade	12-06	4	300	44,081	4,483	4,404	- 79	53/34	31	45
Canon City Oil	12-08	4	800	1,592,174	173,684	166,296	- 7,388	63/28	5	800
Lester Atterberry	12-13	3	187	1,726,030	185,547	164,293	-21,254	55/36	8	76
Beaver Park	12-15	4	2,509	377,699	39,670	50,824	11,154	53/34	277	678
Pleasant Valley	12-16	1	250	1,473,226	161,540	163,301	1,761	70/33	66	0
Reiser Lock	13-01	4	1,000	1,965	171	581	410	53/33	8	0
Bessemer	14-01	1	18,500	12,196,100	1,222,678	1,333,223	110,545	70/55	38,752	14,380
Oxford Farmers	14-02	3	6,000	3,255,291	338,927	274,423	-64,504	55/35	2,273	3,360
West Pueblo Enlarge	14-03	1	235	1,847	160	9,644	9,484	70/43	86	86
Collier	14-04	1	876	67,305	8,091	8,783	692	70/57	476	0
Colorado Canal	14-06	3	35,525	5,447,766	540,229	708,867	168,638	55/53	2,579	0
Lake Henry	14-07	4	6,131	844,950	85,925	101,724	15,799	55/33	166	0

Table B-3 (Con't)

			BENEFIT-COST				OTHER CHARACTERISTIC			
System	Map No.	Level of 2/ Improvement	Acres Served Ac.	Install Cost $	Avg Ann 3/ Cost $	Avg Ann 3/ Benefit $	Net Benefit $	System Irr 1/ Eff. %	Salinity Reduction Tons	Prime Lands With Full Water Ac.
Palmer	16-07	4	500	201,783	21,783	17,981	- 3,802	53/33	8	0
Otero	17-01	4	5,595	2,201,455	235,685	185,606	-50,079	53/33	531	0
Fort Lyon	17-02	4	77,376	10,824,530	1,101,853	1,182,058	80,205	53/33	16,073	12,247
Holbrook	17-03	4	9,741	2,389,440	243,356	217,227	-26,129	53/34	3,245	0
Rocky Ford	17-04	2	5,600	6,682,310	689,334	597,683	-91,651	60/34	3,723	3,680
Catlin	17-05	2	12,750	6,311,285	653,233	792,517	139,284	60/33	7,366	7,650
Lucero	18-07	4	225	231,123	24,810	18,181	- 6,629	53/31	5	0
Highland	19-15	4	1,905	527,668	54,988	53,642	- 1,346	53/34	313	83
Buffalo	67-01	3	3,750	1,920,368	188,664	160,627	-28,037	55/38	3,667	1,881
Amity	67-02	4	25,145	3,047,846	309,992	346,252	36,260	53/33	5,250	1,651
Fort Bent	67-03	4	4,790	671,506	68,333	58,567	- 9,766	53/33	1,175	2,351
Hyde	67-04	4	718	247,066	26,413	28,028	1,615	53/33	289	388
Manvil	67-05	3	3,000	2,683,213	280,576	220,576	-60,000	53/33	559	0
Lamar	67-06	4	5,963	2,136,086	228,943	270,564	41,621	53/33	1,875	2,939
			241,608	70,325,257	7,230,096	7,481,691	251,595	57/36	89,556	55,907

1/ Conveyance eff/on-farm efficiency.
2/ Level of Improvement 1-High, 2-Med High, 3-Med Low, 4-Low, BC Ratio 0.75 or Greater.
3/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits. Average Annual Costs include OM&R.

Table B-4 - Irrigation System Characteristics
Present Level
Arkansas River Basin, Colorado

System	Map No.	ACRES: Present	ACRES: Adj. Ac to Optimize Net Return	WATER SUPPLIES ARE INSUFFICIENT: Full Water Supply	WATER SUPPLIES ARE INSUFFICIENT: Short Water Supply	WATER SUPPLIES ARE INSUFFICIENT: Water Shortage	POOR QUALITY IRR. WATER MGT: Canal Seepage	POOR QUALITY IRR. WATER MGT: On-Farm Losses	POOR QUALITY IRR. WATER MGT: System Irr Eff Conv/on-farm	POOR QUALITY IRR WATER: Salt in SRF	POOR QUALITY IRR WATER: Salt in GWR	MORE BENEFICIAL WATER USE: Crop C.U.	MORE BENEFICIAL WATER USE: Phreat-Wetland ET	RETURN FLOWS: Surface Return Flow	RETURN FLOWS: Net Gr. Water Recharge
		Ac	Ac	Ac	Ac	AF	AF	AF	%	Tons	Tons	AF	AF	AF	AF
Fountain Mut	10-2	3,000	3,000	1,000	2,000	849	5,901	2,720	50/54	879	11,137	3,184	80	431	8,110
Bowen	11-17	2,000	2,000	0	2,000	2,076	2,093	1,466	50/30	104	653	627	0	356	3,203
North Fork	11-22	2,600	2,600	357	2,243	2,875	1,918	1,343	50/30	95	599	575	26	326	2,909
Canon City Hyd.	12-2	4,000	3,350	1,472	2,528	3,309	8,742	8,070	60/38	2,131	4,274	5,042	109	4,236	12,466
Grandview	12-3	1,266	1,038	537	729	1,409	1,774	1,596	60/40	428	856	1,064	140	851	2,378
Harrington	12-5	200	179	13	187	319	292	186	50/36	265	1,166	106	163	48	266
Cascade	12-6	500	300	75	425	701	188	132	50/30	178	784	56	61	32	227
Canon City Oil Cr.	12-8	800	800	800	0	0	4,129	4,407	60/29	215	2,757	1,787	12	427	8,097
Lester Atterberry	12-13	220	187	59	161	247	652	420	50/36	44	328	232	0	107	965
Beaver Park	12-15	3,482	2,416	729	2,753	5,030	4,569	3,199	50/30	1,077	6,654	1,370	284	777	6,708
Pleasant Valley	12-16	250	250	0	250	126	1,187	872	50/30	43	685	377	0	106	2,015
Risser Locke	13-1	1,000	1,000	0	1,000	780	535	374	50/30	70	201	161	24	171	714
Bessemer	14-1	20,000	13,600	5,000	15,000	23,157	27,500	22,683	50/30	1,296	122,122	9,722	0	2,509	42,769
Oxford Farmer	14-2	6,000	5,536	1,400	4,600	6,446	8,418	11,233	50/30	2,244	21,878	4,815	1,105	1,965	8,952
W. Pueblo Enlarge	14-3	235	235	0	235	350	678	475	50/30	30	447	203	0	58	1,095
Collier	14-4	1,062	876	115	947	1,763	739	671	50/30	65	1,265	286	0	70	1,121
Colorado	14-6	49,000	35,525	489	48,511	91,100	17,332	21,669	50/30	1,830	28,350	9,288	55,678	1,950	-32,251

Table B-4 (Con't)

		ACRES		WATER SUPPLIES ARE INSUFFICIENT			POOR QUALITY IRR. WATER MGT			POOR QUALITY IRR WATER		MORE BENEFICIAL WATER USE		RETURN FLOWS	
System	Map No.	Present	Adj. Ac to Optimize Net Return	Full Water Supply	Short Water Supply	Water Shortage	Canal Seepage	On-Farm Losses	System Irr Eff Conv/on-farm	Salt in SRF	Salt in GWR	Crop C.U.	Phreat-Wetland ET	Surface Return Flow	Net Gr. Water Recharge
		Ac	Ac	Ac	Ac	AF	AF	AF	%	Tons	Tons	AF	AF	AF	AF
Lake Henry	14-7	9,017	5,973	95	8,922	14,665	4,029	2,820	50/30	643	5,029	1,209	0	685	6,164
Palmer	16-7	500	500	50	450	968	448	314	50/30	31	233	134	0	76	686
Otero	17-1	6,661	5,595	1,524	5,137	10,950	2,090	4,667	50/30	312	4,167	2,001	74	338	1,768
Fort Lyon	17-2	93,000	73,451	11,811	81,189	161,716	66,870	69,699	50/30	27,854	481,314	29,871	13,534	13,657	76,678
Holbrook	17-3	16,000	9,600	2,476	13,524	29,167	18,451	13,983	50/30	3,396	4,249	5,994	17,352	3,243	10,313
Rocky Ford	17-4	8,000	5,600	3,062	4,938	8,781	18,661	15,160	50/34	6,001	72,771	7,643	598	5,073	24,009
Catlin	17-5	18,886	12,750	8,265	10,621	24,864	31,395	30,470	50/32	6,476	136,804	14,114	283	6,186	42,206
Lucero	18-7	225	225	12	213	137	560	382	50/32	86	237	178	0	150	792
Highland	19-15	3,000	1,905	34	2,966	4,452	1,286	1,124	50/30	544	7,819	482	0	241	1,850
Buffalo	67-1	6,000	3,750	1,651	4,349	7,539	8,517	6,371	50/31	4,339	58,690	2,800	88	744	13,402
Amity	67-2	34,683	25,145	867	33,816	55,306	21,453	22,952	50/30	26,689	99,655	9,837	1,982	4,441	26,648
Fort Bent	67-3	6,500	4,508	1,694	4,806	8,526	5,214	6,854	50/30	7,253	16,405	2,938	57	1,207	6,227
Hyde	67-4	1,000	675	339	661	1,291	482	1,254	50/30	490	1,543	536	5	87	336
Manvil	67-5	5,000	3,000	250	4,750	8,819	500	2,258	50/30	1,455	7,343	967	142	276	- 385
Lamar	67-6	9,000	5,541	2,586	6,414	12,560	9,928	9,162	50/30	5,388	45,609	3,927	1,184	955	13,791
		313,087	231,110	46,762	266,325	490,278	276,531	268,986	51/31	101,951	1,145,984	121,523	92,981	51,779	294,229

Table B-5 - Irrigation System Characteristics Impacted
By Plan To Maxamize Net Farm Income (Plan A)
Arkansas River Basin, Colorado

		ACRES		WATER SUPPLIES ARE INSUFFICIENT			POOR QUALITY IRR. WATER MGT			POOR QUALITY IRR WATER		MORE BENEFICIAL WATER USE		RETURN FLOWS	
System	Map No.	Level of 1/ Improv.	Adj. Ac to Optimize Net Return	Full Water Supply	Short Water Supply	Water Shortage	Canal Seepage	On-Farm Losses	System Irr Eff Conv/on-farm	Salt in SRF	Salt in GWR	Crop C.U.	Phreat-Wetland ET	Surface Return Flow	Net Gr. Water Recharge
			Ac	Ac	Ac	AF	AF	AF	%	Tons	Tons	AF	AF	AF	AF
Fountain Mut	10-2	4	3,000	961	2,039	613	5,547	2,817	53/55	852	10,804	3,438	80	418	7,866
Bowen	11-17	4	2,000	0	2,000	1,997	1,968	1,487	53/33	101	634	732	0	345	3,109
North Fork	11-22	4	2,600	234	2,366	2,873	1,803	1,362	53/33	93	581	672	26	317	2,823
Canon City Hyd.	12-2	4	3,350	1,659	1,691	1,642	8,086	8,659	63/37	2,091	4,278	5,109	109	4,158	12,479
Grandview	12-3	4	1,038	681	357	699	1,641	1,592	63/43	408	823	1,201	140	811	2,282
Harrington	12-5	4	180	15	165	291	274	200	53/35	264	1,161	110	163	47	263
Cascade	12-6	4	300	45	255	402	177	133	53/34	172	759	67	61	31	218
Canon City Oil Cr.	12-8	4	800	800	0	0.	3,820	4,706	63/28	214	2,753	1,797	12	426	8,087
Lester Atterberry	12-13	4	187	69	118	167	613	451	53/35	43	326	241	0	106	958
Beaver Park	12-15	4	2,509	678	1,831	3,207	4,295	3,193	53/34	1,039	6,415	1,651	284	749	6,456
Pleasant Valley	12-16	1	250	0	250	12	712	1,180	70/33	39	623	569	0	96	1,833
Risser Locke	13-1	4	1,000	0	1,000	752	503	380	53/33	67	196	187	24	164	695
Bessemer	14-1	4	13,600	3,000	10,600	12,466	25,850	22,817	53/33	1,257	118,008	11,238	0	2,433	41,329
Oxford Farmer	14-2	4	5,954	3,314	2,640	5,742	7,913	11,091	53/33	2,170	20,609	5,462	1,105	1,900	8,368
W. Pueblo Enlarge	14-3	1	235	86	149	146	407	541	70/43	24	367	408	0	47	901
Collier	14-4	4	876	127	749	1,292	695	672	53/33	63	1,218	330	0	68	1,080
Colorado	14-6	4	35,525	1,806	33,719	63,616	16,292	21,438	53/33	1,770	26,887	10,559	55,678	1,887	-33,459

Table B-5 (Con't)

System	Map No.	Level 1/ of Improv.	ACRES: Adj. Ac to Optimize Net Return	WATER SUPPLIES ARE INSUFFICIENT: Full Water Supply	Short Water Supply	Water Shortage	POOR QUALITY IRR. WATER MGT: Canal Seepage	On-Farm Losses	System Irr Eff	POOR QUALITY IRR WATER: Salt in SRF	Salt in GWR	MORE BENEFICIAL WATER USE: Crop C.U.	Phreat-Wetland ET	RETURN FLOWS: Surface Return Flow	Net Gr. Water Recharge
			Ac	Ac	Ac	AF	AF	AF	Conv/on-farm %	Tons	Tons	AF	AF	AF	AF
Lake Henry	14-7	4	6,131	57	6,074	9,558	3,787	2,861	53/33	624	4,882	1,410	0	665	5,984
Palmer	16-7	4	500	55	445	936	422	319	53/33	30	226	156	0	74	666
Otero	17-1	4	5,595	1,624	3,971	8,359	1,965	4,552	53/33	301	3,647	2,241	74	326	1,539
Fort Lyon	17-2	4	77,376	12,247	65,129	129,904	62,858	69,400	53/33	26,975	466,120	34,182	13,534	13,226	72,798
Holbrook	17-3	4	9,741	3,271	6,470	14,588	17,344	13,848	53/34	3,266	4,249	7,236	17,352	3,119	9,194
Rocky Ford	17-4	4	5,600	3,482	2,118	3,752	17,542	15,165	53/37	5,803	69,967	8,758	598	4,906	23,061
Catlin	17-5	4	12,750	7,650	5,100	9,196	29,511	29,900	53/36	6,220	129,694	16,568	283	5,941	39,998
Lucero	18-7	4	225	13	212	148	526	407	53/31	83	235	186	0	146	787
Highland	19-15	4	1,905	83	1,822	2,613	1,209	1,111	53/34	524	7,526	573	0	232	1,769
Buffalo	67-1	4	3,750	1,670	2,080	3,347	8,006	6,202	53/36	4,141	55,884	3,481	88	710	12,757
Amity	67-2	4	25,145	1,651	23,495	36,162	20,166	22,831	53/33	25,842	95,242	11,246	1,982	4,300	25,380
Fort Bent	67-3	4	4,790	2,351	2,438	4,729	4,901	6,770	53/33	7,013	15,470	3,335	57	1,167	5,870
Hyde	67-4	4	718	388	330	662	454	1,219	53/33	473	1,271	600	5	84	276
Manvil	67-5	4	3,000	300	2,700	4,781	470	2,181	53/33	1,398	7,059	1,074	142	265	- 481
Lamar	67-6	4	5,963	2,939	3,024	6,084	9,332	9,168	53/33	5,219	43,903	4,517	1,184	925	13,231
			236,593	51,256	185,337	330,736	259,089	268,653	53/34	98,579	1,101,817	139,334	92,981	50,089	278,117

1/ Levels of Improvement = 1-High, 2-Med High, 3-Med Low, 4-Low.

Table B-6 - Irrigation System Characteristics Impacted
By Plan of Maximum Economically Feasible Improvements (Plan B)
Arkansas River Basin, Colorado

			ACRES	WATER SUPPLIES ARE INSUFFICIENT			POOR QUALITY IRR. WATER MGT			POOR QUALITY IRR WATER		MORE BENEFICIAL WATER USE		RETURN FLOWS	
System	Map No.	Level of 1/ Improv.	Adj. Ac to Optimize Net Return	Full Water Supply	Short Water Supply	Water Shortage	Canal Seepage	On-Farm Losses	System Irr Eff Conv/on-farm	Salt in SRF	Salt in GWR	Crop C.U.	Phreat-Wetland ET	Surface Return Flow	Net Gr. Water Recharge
			Ac	Ac	Ac	AF	AF	AF	%	Tons	Tons	AF	AF	AF	AF
Fountain Mut	10-2	4	3,000	961	2,039	613	5,547	2,817	53/55	852	10,804	3,438	80	418	7,866
Bowen	11-17	3	2,000	0	2,000	1,923	1,884	1,497	53/35	99	621	806	0	338	3,043
North Fork	11-22	4	2,600	234	2,366	2,873	1,803	1,362	53/33	93	581	672	26	317	2,823
Canon City Hyd.	12-2	3	3,350	1,785	1,565	1,360	7,649	8,815	65/38	2,041	4,217	5,390	109	4,058	12,297
Grandview	12-3	2	1,108	851	257	505	1,330	1,552	70/50	356	738	1,552	31	709	2,141
Harrington	12-5	4	180	15	165	291	274	200	53/35	264	1,161	110	163	47	263
Cascade	12-6	4	300	45	255	402	177	133	53/34	172	759	67	61	31	218
Canon City Oil Cr.	12-8	4	800	800	0	0	3,820	4,706	63/28	214	2,753	1,797	12	426	8,087
Lester Atterberry	12-13	3	187	76	111	153	587	463	55/36	43	321	255	0	105	945
Beaver Park	12-15	4	2,509	678	1,831	3,207	4,295	3,193	53/34	1,039	6,415	1,651	284	749	6,456
Pleasant Valley	12-16	1	250	0	250	12	712	1,180	70/33	39	623	569	0	96	1,833
Risser Locke	13-1	4	1,000	0	1,000	752	503	380	53/33	67	196	187	24	164	695
Bessemer	14-1	1	18,500	14,380	4,120	6,421	16,500	19,533	70/55	931	83,735	23,872	0	1,802	29,326
Oxford Farmer	14-2	3	6,000	3,360	2,640	5,364	7,576	10,979	55/35	2,119	19,730	5,911	276	1,855	9,345
W. Pueblo Enlarge	14-3	1	235	86	149	146	407	541	70/43	24	367	408	0	47	901
Collier	14-4	1	876	179	697	984	444	541	70/57	45	809	712	0	49	717
Colorado	14-6	3	35,525	2,131	33,394	62,370	15,599	21,248	55/35	1,728	25,873	11,442	55,678	1,842	-34,297

Table B-6 (Con't)

System	Map Unit	Level 1/ of Improv.	ACRES	WATER SUPPLIES ARE INSUFFICIENT			POOR QUALITY IRR. WATER MGT			POOR QUALITY IRR WATER		MORE BENEFICIAL WATER USE		RETURN FLOWS	
			Adj. Ac to Optimize Net Return	Full Water Supply	Short Water Supply	Water Shortage	Canal Seepage	On-Farm Losses	System Irr Eff Conv/on-farm	Salt in SRF	Salt in GWR	Crop C.U.	Phreat-Wetland ET	Surface Return Flow	Net Gr. Water Recharge
			Ac	Ac	Ac	AF	AF	AF	%	Tons	Tons	AF	AF	AF	AF
Lake Henry	14-7	4	6,131	57	6,074	9,558	3,787	2,861	53/33	624	4,882	1,410	0	665	5,984
Palmer	16-7	4	500	55	445	936	422	319	53/33	30	226	156	0	74	666
Otero	17-1	4	5,595	1,624	3,971	8,359	1,965	4,552	53/33	301	3,647	2,241	74	326	1,539
Fort Lyon	17-2	4	77,376	12,247	65,129	129,904	62,858	69,400	53/33	26,975	466,120	34,182	13,534	13,226	72,798
Holbrook	17-3	4	9,741	3,271	6,470	14,588	17,344	13,848	53/34	3,266	4,249	7,236	17,352	3,119	9,194
Rocky Ford	17-4	2	5,600	3,680	1,920	2,748	14,929	17,509	60/34	5,756	69,293	9,027	598	4,866	23,833
Catlin	17-5	2	12,750	7,650	5,100	4,749	25,116	34,296	60/33	6,220	129,694	16,567	283	5,941	39,998
Lucero	18-7	4	225	13	212	148	526	407	53/31	83	235	186	0	146	787
Highland	19-15	4	1,905	83	1,822	2,613	1,209	1,111	53/34	524	7,526	573	0	232	1,769
Buffalo	67-1	3	3,750	1,881	1,869	3,115	7,666	6,166	55/38	4,036	54,326	3,857	88	692	12,398
Amity	67-2	4	25,146	1,651	23,495	36,162	20,166	22,831	53/33	25,842	95,242	11,246	1,982	4,300	25,380
Fort Bent	67-3	4	4,789	2,351	2,438	4,729	4,901	6,770	53/33	7,013	15,470	3,335	57	1,167	5,870
Hyde	67-4	4	718	388	330	662	454	1,219	53/33	473	1,271	600	5	84	276
Manvil	67-5	4	3,000	300	2,700	4,781	470	2,181	53/33	1,398	7,059	1,074	142	265	- 481
Lamar	67-6	4	5,963	2,939	3,024	6,084	9,332	9,168	53/33	5,219	43,903	4,517	1,184	925	13,231
			241,609	63,771	177,838	316,512	240,252	271,778	57/36	97,886	1,053,126	155,046	92,013	49,081	264,901

1/ Levels of Improvement = 1-High, 2-Med High, 3-Med Low, 4-Low.

Table B-7 - EFFECTS OF IRRIGATION PROJECT IMPLEMENTATION
Arkansas River Basin, Colorado

Present Level

NED

Component System No	Increased Value of Goods and Service: Annual Crop Benefits $	Other Benefits $	Annual Project Benefits $	Annual Net Benefits $	Irrigation Structures and Land Treatment Cost: Annual Installation Cost $	Annual OM&R $	Total Annual $	Crop Distribution: Alfalfa Ac.	Corn Ac.	Grass Hay (Other)	Grass Pasture Ac.	Orchards Ac.	Spring Grain Ac.	Sorghum Ac.	Vegetables Ac.	Winter Wheat Ac.	Total Ac.
10-02	0	0	0	0	0	0	0	500	500	2,000	-	-	-	-	-	-	3,000
11-16	0	0	0	0	0	0	0	1,000	-	1,000	-	-	-	-	-	-	2,000
11-22	0	0	0	0	0	0	0	-	-	2,080	-	-	390	-	-	130	2,600
12-02	0	0	0	0	0	0	0	2,100	600	800	-	400	-	-	100	-	4,000
12-03	0	0	0	0	0	0	0	657	454	-	-	90	-	-	65	-	1,266
12-05	0	0	0	0	0	0	0	120	-	40	-	-	40	-	-	-	200
12-06	0	0	0	0	0	0	0	250	-	-	-	-	75	75	-	100	500
12-08	0	0	0	0	0	0	0	600	-	-	-	100	-	-	100	-	800
12-13	0	0	0	0	0	0	0	132	88	-	-	-	-	-	-	-	220
12-15	0	0	0	0	0	0	0	1,499	-	-	1,009	-	627	104	243	-	3,482
12-16	0	0	0	0	0	0	0	-	-	250	-	-	-	-	-	-	250
13-01	0	0	0	0	0	0	0	-	-	1,000	-	-	-	-	-	-	1,000
14-01	0	0	0	0	0	0	0	4,000	10,000	-	-	-	1,000	-	5,000	-	20,000
14-02	0	0	0	0	0	0	0	2,400	3,000	-	-	-	-	-	600	-	6,000
14-03	0	0	0	0	0	0	0	235	-	-	-	-	-	-	-	-	235
14-04	0	0	0	0	0	0	0	478	424	-	-	-	106	-	54	-	1,062
14-06	0	0	0	0	0	0	0	24,500	12,251	-	-	-	-	11,760	489	-	49,000
14-07	0	0	0	0	0	0	0	5,065	1,930	-	-	-	-	1,927	95	-	9,017
16-07	0	0	0	0	0	0	0	-	-	450	-	-	50	-	-	-	500
17-01	0	0	0	0	0	0	0	2,665	-	-	-	-	-	2,665	-	1,331	6,662
17-02	0	0	0	0	0	0	0	41,850	9,300	-	-	-	9,300	27,900	4,650	-	93,000
17-03	0	0	0	0	0	0	0	9,600	3,200	-	-	-	-	3,200	-	-	16,000
17-04	0	0	0	0	0	0	0	3,200	3,200	-	-	-	-	-	1,600	-	8,000
17-05	0	0	0	0	0	0	0	8,500	7,550	-	-	-	-	-	2,836	-	18,886
18-07	0	0	0	0	0	0	0	110	-	45	45	-	12	-	-	13	225
19-15	0	0	0	0	0	0	0	1,800	-	-	-	-	-	900	-	300	3,000
67-01	0	0	0	0	0	0	0	2,400	600	-	-	-	-	2,400	300	300	6,000
67-02	0	0	0	0	0	0	0	15,606	-	-	-	-	1,735	17,342	-	-	34,683
67-03	0	0	0	0	0	0	0	3,251	649	-	-	-	651	1,300	-	649	6,500
67-04	0	0	0	0	0	0	0	500	300	-	-	-	50	100	-	50	1,000
67-05	0	0	0	0	0	0	0	3,000	250	-	-	-	-	1,500	250	-	5,000
67-06	0	0	0	0	0	0	0	4,500	1,800	-	-	-	450	1,800	-	450	9,000
Total	0	0	0	0	0	0	0	140,518	56,096	7,665	1,054	590	14,486	72,973	16,382	1,323	313,087

System No	Change In Crop Yields: Alfalfa Ton/Ac.	Corn Ton/Ac.	Grass Hay (Other) Ton/Ac.	Grass Pasture Aum/Ac.	Orchards Bu/Ac.	Spring Grain Bu/Ac.	Sorghum Cwt/Ac.	Vegetables Ton/Ac.	Winter Wheat Bu/Ac.
10-02	6.0	20.0	4.3	-	-	-	-	-	-
11-16	1.07	-	0.73	-	-	-	-	-	-
11-22	-	-	0.63	-	-	46.86	-	-	21.58
12-02	2.57	23.90	1.32	-	400.0	-	-	10.0	-
12-03	2.02	23.16	-	-	400.0	-	-	10.0	-
12-05	1.18	-	0.91	-	-	38.66	-	-	-
12-06	1.05	-	-	-	-	26.24	25.00	-	12.38
12-08	3.02	-	-	-	400.0	-	-	10.0	-
12-13	1.81	23.90	-	-	-	-	-	-	-
12-15	1.59	-	-	2.76	-	10.46	26.0	10.0	-
12-16	-	-	1.74	-	-	-	-	-	-
13-01	-	-	1.08	-	-	-	-	-	-
14-01	2.00	18.45	-	-	-	19.88	-	10.0	-
14-02	2.24	18.48	-	-	-	-	-	10.0	-
14-03	2.72	-	-	-	-	-	-	-	-
14-04	1.57	16.67	-	-	-	17.09	-	10.0	-
14-06	1.54	16.44	-	-	-	-	10.8	10.0	-
14-07	1.19	15.15	-	-	-	-	20.3	10.0	-
16-07	-	-	0.64	-	-	26.30	-	-	-
17-01	1.01	-	-	-	-	-	21.06	-	33.01
17-02	1.60	15.06	-	-	-	29.80	16.92	10.0	-
17-03	1.23	16.01	-	-	-	-	20.51	-	-
17-04	1.86	18.02	-	-	-	-	-	10.0	-
17-05	1.35	18.20	-	-	-	-	-	10.0	-
18-07	1.14	-	1.03	3.20	-	26.30	-	-	29.1
19-15	0.76	-	-	-	-	-	30.31	-	21.8
67-01	2.12	15.9	-	-	-	-	42.04	10.0	45.1
67-02	2.77	-	-	-	-	52.85	41.78	-	-
67-03	1.99	17.92	-	-	-	13.44	67.09	-	47.69
67-04	1.79	15.90	-	-	-	12.30	68.70	-	33.87
67-05	1.87	15.90	-	-	-	-	33.66	10.0	-
67-06	1.92	16.35	-	-	-	12.54	66.03	-	41.73
Total Yield - Ac. X Yiels/Ac.	Ton	Ton	Ton	AUM	BU	BU	CWT	Ton	BU
Total	244,575	960,230	13,581	2,929	236,000	344,733	1,880,414	113,820	119,837

Table B-7 (Con't)

	EQ						OSE
Component	Water and Land Quality		Biological Measures			Visual Characteristics	Job Creation or Loss Project Construction
System No	Salt in Return Flows and Ground Recharge Tons	Prime Agr. Lands with Full Water Supply Ac.	Wetland Ac.	Phreato-phytes Ac.	Cotton Woods Ac.	Land Irrigated Ac.	(Total unskilled and semiskilled Labor) job/yrs
10-02	12,016	1,000	0	40	0	3,000	0
11-17	757	0	0	0	0	2,000	0
11-22	694	0	4	6	0	2,600	0
12-02	6,405	1,472	20	0	0	4,000	0
12-03	1,284	537	25	0	1	1,266	0
12-05	1,431	13	30	0	0	200	0
12-06	962	75	11	1	0	500	0
12-08	2,972	800	0	0	3	800	0
12-13	372	59	0	0	0	220	0
12-15	7,731	729	45	16	0	3,482	0
12-16	728	0	0	0	0	250	0
13-01	271	0	4	1	0	1,000	0
14-01	123,418	5,000	0	0	0	20,000	0
14-02	24,122	1,400	200	0	0	6,000	0
14-03	477	0	0	0	0	235	0
14-04	1,330	0	0	0	0	1,062	0
14-06	30,180	0	9,838	155	233	49,000	0
14-07	5,672	0	0	0	0	9,017	0
16-07	264	0	0	0	0	500	0
17-01	4,479	0	0	6	13	6,661	0
17-02	381,117	11,811	2,047	335	98	93,000	0
17-03	80,434	0	2,553	486	188	16,000	0
17-04	78,772	3,062	91	9	7	8,000	0
17-05	143,280	8,265	40	0	10	18,886	0
18-07	323	0	0	0	0	225	0
19-15	7,210	34	0	0	0	3,000	0
67-01	62,029	1,651	0	29	3	6,000	0
67-02	126,334	867	206	149	93	34,683	0
67-03	23,658	1,694	1	13	4	6,500	0
67-04	2,033	339	0	2	0	1,000	0
67-05	735	0	17	0	10	5,000	0
67-06	50,997	2,586	200	2	4	9,000	0
Total	1,182,487	41,394	15,332	1,250	667	313,087	0

Table B-8 - EFFECTS OF IRRIGATION PROJECT IMPLEMENTATION
Arkansas River Basin, Colorado

Plan to Maximize Net Farm Income (Plan A)

NED

Component	Increased Value of Goods and Service 1/				Irrigation Structures and Land Treatment Cost 1/		
System No	Annual Crop Benefits $	Other Benefits $	Annual Project Benefits $	Annual Net Benefits $	Annual Installation Cost $	Annual OM&R $	Total Annual $
10-02	12,555	0	12,555	3,386	7,890	1,280	9,170
11-16	1,794	17,687	10,481	- 4,616	19,496	4,601	24,097
11-22	6,860	0	6,860	2,513	3,763	584	4,347
12-02	63,546	161,369	224,915	46,099	142,523	36,293	178,816
12-03	57,617	0	57,617	53,706	3,326	584	3,910
12-05	561	17,687	18,248	- 3,270	17,257	4,261	21,518
12-06	4,404	0	4,404	- 79	3,825	658	4,483
12-08	4,927	161,369	166,296	- 7,388	138,169	35,515	173,684
12-13	2,603	17,687	20,290	854	15,487	3,949	19,436
12-15	33,137	17,687	50,824	11,154	32,777	6,893	39,670
12-16	1,932	161,369	163,301	1,761	127,847	33,693	161,540
13-01	581	0	581	411	171	0	171
14-01	479,439	0	479,439	432,715	40,243	6,480	46,723
14-02	87,626	161,369	248,995	74,443	141,591	35,961	177,552
14-03	9,644	0	9,644	9,484	160	0	160
14-04	5,190	0	5,190	5,020	171	0	171
14-06	633,902	0	633,902	465,593	144,149	24,160	168,309
14-07	101,724	0	101,724	15,800	73,325	12,600	85,925
16-07	294	17,687	17,981	- 3,802	17,490	4,293	21,783
17-01	24,237	161,369	184,606	-50,079	191,042	44,643	243,356
17-02	1,182,058	0	1,182,058	80,205	939,353	162,500	1,101,853
17-03	217,227	0	217,227	-26,128	207,356	36,000	243,356
17-04	435,529	161,369	596,898	353,555	197,590	45,793	243,383
17-05	792,517	0	792,517	583,842	177,935	30,740	208,675
18-07	493	17,687	18,181	- 6,629	20,057	4,753	24,810
19-15	35,955	17,687	53,642	- 1,346	45,791	9,197	54,988
67-01	149,023	0	149,023	127,279	18,644	3,100	21,744
67-02	346,252	0	346,252	36,260	262,492	45,500	309,992
67-03	58,567	0	58,567	- 9,766	58,273	10,060	68,333
67-04	10,341	17,687	28,028	1,615	21,440	4,973	26,413
67-05	55,127	161,369	216,497	- 5,668	179,504	42,661	222,165
67-06	109,195	161,369	270,564	41,621	185,370	43,573	228,943
Total	4,924,857	1,432,448	6,357,305	2,228,545	3,437,507	695,298	4,132,805

Component	Crop Distribution									
System No	Alfalfa Ac.	Corn Ac.	Grass Hay (Other)	Grass Pasture Ac.	Orchards Ac.	Spring Grain Ac.	Sorghum Ac.	Vegetables Ac.	Winter Wheat Ac.	Total Ac.
10-02	550	300	2,150	-	-	-	-	-	-	3,000
11-16	1,100	-	900	-	-	-	-	-	-	2,000
11-22	-	-	2,288	-	-	234	-	-	78	2,600
12-02	1,260	660	880	-	440	-	-	110	-	3,350
12-03	394	476	-	-	99	-	-	68	-	1,038
12-05	132	-	24	-	-	24	-	-	-	180
12-06	150	-	-	-	-	45	45	-	60	300
12-08	630	-	-	-	60	-	-	110	-	900
12-13	112	75	-	-	-	-	-	-	-	187
12-15	1,143	-	-	782	-	376	62	146	-	2,509
12-16	-	-	250	-	-	-	-	-	-	250
13-01	-	-	1,000	-	-	-	-	-	-	1,000
14-01	4,000	6,000	-	-	-	600	-	3,000	-	13,600
14-02	2,640	2,954	-	-	-	-	-	360	-	5,954
14-03	235	-	-	-	-	-	-	-	-	235
14-04	287	466	-	-	-	64	-	59	-	876
14-06	20,825	7,351	-	-	-	-	7,056	293	-	35,525
14-07	3,601	1,316	-	-	-	-	1,156	57	-	6,131
16-07	-	-	445	-	-	55	-	-	-	500
17-01	1,599	-	-	-	-	-	2,931	-	1,065	5,595
17-02	41,850	7,998	-	-	-	7,998	16,740	2,790	-	77,376
17-03	5,760	2,061	-	-	-	-	1,920	-	-	9,741
17-04	1,920	1,920	-	-	-	-	-	1,760	-	5,600
17-05	5,100	4,530	-	-	-	-	-	3,120	-	12,750
18-07	121	-	49	33	-	13	-	-	8	225
19-15	1,170	-	-	-	-	-	540	-	195	1,905
67-01	1,440	360	-	-	-	-	1,440	330	180	3,705
67-02	13,266	-	-	-	-	1,474	10,405	-	-	25,145
67-03	1,951	548	-	-	-	391	1,430	-	470	4,790
67-04	300	248	-	-	-	30	110	-	30	718
67-05	1,800	150	-	-	-	-	900	150	-	3,000
67-06	2,700	1,080	-	-	-	270	1,632	-	281	5,963
Total	116,036	38,493	7,986	815	599	11,574	46,367	12,353	2,367	236,590

Component	Change In Crop Yields								
System No	Alfalfa Ton/Ac.	Corn Ton/Ac.	Grass Hay (Other) Ton/Ac.	Grass Pasture Aum/Ac.	Orchards Bu/Ac.	Spring Grain Bu/Ac.	Sorghum Cwt/Ac.	Vegetables Ton/Ac.	Winter Wheat Bu/Ac.
10-02	6.0	20.0	4.53	-	-	-	-	-	-
11-16	1.09	-	0.73	-	-	-	-	-	-
11-22	-	-	0.65	-	-	47.6	-	-	26.66
12-02	2.91	23.90	1.49	-	400.0	-	-	10.0	-
12-03	2.03	23.48	-	-	400.0	-	-	10.0	-
12-05	1.22	-	0.93	-	-	42.16	-	-	-
12-06	1.05	-	-	-	-	29.53	25.00	-	17.92
12-08	3.02	-	-	-	400.0	-	-	10.0	-
12-13	2.08	23.90	-	-	-	-	-	-	-
12-15	2.00	-	-	3.03	-	10.46	26.00	10.0	-
12-16	-	-	1.90	-	-	-	-	-	-
13-01	-	-	1.09	-	-	-	-	-	-
14-01	2.09	17.16	-	-	-	19.88	-	10.0	-
14-02	2.24	19.60	-	-	-	-	-	10.0	-
14-03	3.52	-	-	-	-	-	-	-	-
14-04	1.57	16.67	-	-	-	17.99	-	10.0	-
14-06	1.74	16.13	-	-	-	-	10.80	10.0	-
14-07	1.34	15.44	-	-	-	-	38.14	10.0	-
16-07	-	-	0.65	-	-	26.30	-	-	-
17-01	1.01	-	-	-	-	-	26.01	-	26.83
17-02	1.84	16.01	-	-	-	34.26	23.43	10.0	-
17-03	1.29	16.16	-	-	-	-	39.28	-	-
17-04	1.86	18.20	-	-	-	-	-	10.0	-
17-05	1.35	18.20	-	-	-	-	-	10.0	-
18-07	2.16	-	1.03	3.35	-	26.30	-	-	29.10
19-15	0.80	-	-	-	-	-	37.22	-	28.70
67-01	2.49	15.90	-	-	-	-	63.44	10.0	45.10
67-02	3.25	-	-	-	-	65.57	55.61	-	-
67-03	2.29	17.34	-	-	-	13.44	69.82	-	60.06
67-04	2.18	15.90	-	-	-	12.31	68.70	-	45.17
67-05	2.18	15.90	-	-	-	-	35.12	10.0	-
67-06	2.21	16.30	-	-	-	16.18	68.85	-	48.50
	Total Yield - Ac. X Yiels/Ac.								
	Ton	Ton	Ton	AUM	BU	BU	CWT	Ton	BU
Total	229,715	660,162	15.121	2,480	239,600	412,935	1,708,349	123,530	88,886

Table B-8 (con't)

	EQ						OSE
Component	Water and Land Quality		Biological Measures			Visual Characteristics	Job Creation or Loss Project Construction
System No	Salt in Return Flows and Ground Recharge Tons	Prime Agr. Lands with Full Water Supply Ac.	Wetland Ac.	Phreatophytes Ac.	Cotton Woods Ac.	Land Irrigated Ac.	(Total unskilled and semiskilled Labor) job/yrs
10-02	11,656	961	0	40	0	3,000	0.04
11-17	735	0	0	0	0	2,000	0.12
11-22	674	0	4	6	0	2,600	0.02
12-02	6,369	1,659	20	0	0	3,350	0.81
12-03	1,231	681	25	0	1	1,038	0.02
12-05	1,425	15	30	0	0	180	0.10
12-06	931	45	11	1	0	300	0.02
12-08	2,967	800	0	0	3	800	0.78
12-13	369	69	0	0	0	187	0.09
12-15	7,454	678	45	16	0	2,509	0.19
12-16	662	0	0	0	0	250	0.72
13-01	263	0	4	1	0	1,000	0.00
14-01	119,265	3,000	0	0	0	13,600	0.23
14-02	22,779	3,314	200	0	0	5,954	0.81
14-03	391	86	0	0	0	235	0.00
14-04	1,281	0	0	0	0	876	0.00
14-06	28,657	0	9,838	155	233	35,525	0.82
14-07	5,506	0	0	0	0	6,131	0.41
16-07	256	0	0	0	0	500	0.10
17-01	3,948	0	0	6	13	5,595	1.09
17-02	365,044	12,247	2,047	335	98	77,376	5.36
17-03	77,189	0	2,553	486	188	9,741	1.18
17-04	75,770	3,482	91	9	7	5,600	1.12
17-05	135,914	7,650	40	0	10	12,750	1.02
18-07	318	0	0	0	0	225	0.12
19-15	6,897	83	0	0	0	1,905	0.26
67-01	60,025	1,670	0	29	3	3,750	0.10
67-02	121,084	1,651	206	149	93	25,145	1.50
67-03	22,483	2,351	1	13	4	4,790	0.34
67-04	1,744	388	0	2	0	718	0.12
67-05	394	0	17	0	10	3,000	1.02
67-06	49,122	2,939	200	2	4	5,963	1.06
Total	1,132,803	43,683	15,332	1,250	667	236,590	19.57

1/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits.

Table B-9 - EFFECTS OF IRRIGATION PROJECT IMPLEMENTATION
Arkansas River Basin, Colorado

Plan of Maximum Economically Feasible Improvements (Plan B)

NED

Component System No	Increased Value of Goods and Service 1/ Annual Crop Benefits $	Other Benefits $	Annual Project Benefits $	Annual Net Benefits $	Irrigation Structures and Land Treatment Cost 1/ Annual Installation Cost $	Annual OM&R $	Total Annual $
10-02	12,555	0	12,555	3,386	7,890	1,280	9,170
11-16	2,693	17,687	20,380	- 3,717	19,496	4,601	24,097
11-22	6,860	0	6,860	2,513	3,763	584	4,347
12-02	67,183	161,369	228,552	26	185,402	43,124	228,526
12-03	59,224	0	59,224	5,854	45,752	7,618	53,370
12-05	561	17,687	18,248	- 3,270	17,257	4,261	21,518
12-06	4,404	0	4,404	- 79	3,825	658	4,483
12-08	4,927	161,369	166,296	- 7,388	138,169	35,515	173,684
12-13	2,924	161,369	164,293	21,254	149,169	35,762	185,547
12-15	33,137	17,687	50,824	11,154	32,777	6,893	39,670
12-16	1,932	161,369	163,301	1,761	127,847	33,693	161,540
13-01	581	0	581	411	171	0	171
14-01	1,333,223	0	1,333,223	110,546	1,058,378	164,300	1,222,678
14-02	113,054	161,369	274,423	-64,504	282,494	56,433	338,927
14-03	9,644	0	9,644	9,484	160	0	160
14-04	8,783	0	5,190	692	5,841	2,250	8,091
14-06	708,867	0	708,867	168,638	472,257	67,472	540,229
14-07	101,724	0	101,724	15,800	73,325	12,600	85,925
16-07	294	17,687	17,981	- 3,802	17,490	4,293	21,783
17-01	24,237	161,369	185,606	-50,079	191,042	44,643	235,685
17-02	1,182,058	0	1,182,058	80,205	939,353	162,500	1,101,853
17-03	217,227	0	217,227	-26,128	207,356	36,000	243,356
17-04	436,314	161,369	597,683	-91,651	579,891	109,443	689,334
17-05	792,517	0	792,517	139,283	547,693	105,540	653,233
18-07	493	17,687	18,181	- 6,629	20,057	4,753	24,810
19-15	35,955	17,687	53,642	- 1,346	45,791	9,197	54,988
67-01	160,627	0	160,627	-28,036	166,650	22,014	188,664
67-02	346,252	0	346,252	36,260	264,492	45,500	309,992
67-03	58,567	0	58,567	- 9,766	58,273	10,060	68,333
67-04	10,341	17,687	28,028	1,615	21,440	4,973	26,413
67-05	55,207	161,369	220,576	-60,000	232,849	42,727	280,576
67-06	109,195	161,369	270,564	41,621	185,370	43,573	228,943
Total	5,905,560	1,576,130	7,481,691	251,600	6,102,836	1,127,260	7,230,096

Component System No	Crop Distribution Alfalfa Ac.	Corn Ac.	Grass Hay (Other)	Grass Pasture Ac.	Orchards Ac.	Spring Grain Ac.	Sorghum Ac.	Vege-tables Ac.	Winter Wheat Ac.	Total Ac.
10-02	550	300	2,150	-	-	-	-	-	-	3,000
11-16	1,100	-	900	-	-	-	-	-	-	2,000
11-22	-	-	2,288	-	-	234	-	-	78	2,600
12-02	1,260	660	880	-	440	-	-	110	-	3,350
12-03	463	476	-	-	99	-	-	68	-	1,107
12-05	132	-	24	-	-	24	-	-	-	180
12-06	150	-	-	-	-	45	45	-	60	300
12-08	630	-	-	-	60	-	-	110	-	800
12-13	112	75	-	-	-	-	-	-	-	187
12-15	1,143	-	-	782	-	376	62	146	-	2,509
12-16	-	-	250	-	-	-	-	-	-	250
13-01	-	-	1,000	-	-	-	-	-	-	1,000
14-01	4,000	10,500	-	-	-	1,000	-	3,000	-	18,500
14-02	2,640	3,000	-	-	-	-	-	360	-	6,000
14-03	235	-	-	-	-	-	-	-	-	235
14-04	287	466	-	-	-	64	-	57	-	876
14-06	20,825	7,351	-	-	-	-	7,056	293	-	35,525
14-07	3,601	1,316	-	-	-	-	1,156	57	-	6,131
16-07	-	-	445	-	-	55	-	-	-	500
17-01	1,599	-	-	-	-	-	2,931	-	1,065	5,596
17-02	41,850	7,998	-	-	-	7,998	16,740	2,790	-	77,376
17-03	5,760	2,061	-	-	-	-	1,920	-	-	9,741
17-04	1,920	1,920	-	-	-	-	-	1,760	-	5,600
17-05	5,100	4,530	-	-	-	-	-	3,120	-	12,750
18-07	121	-	49	33	-	13	-	-	8	225
19-15	1,170	-	-	-	-	-	540	-	195	1,905
67-01	1,440	360	-	-	-	-	1,440	330	130	3,705
67-02	13,266	-	-	-	-	1,474	10,405	-	-	25,145
67-03	1,951	548	-	-	-	391	1,430	-	470	4,790
67-04	300	248	-	-	-	30	110	-	30	718
67-05	1,800	150	-	-	-	-	900	150	-	3,000
67-06	2,700	1,080	-	-	-	270	1,632	-	281	5,963
Total	116,105	43,039	7,986	815	599	46,367	46,367	12,353	2,367	241,605

Component System No	Change In Crop Yields Alfalfa Ton/Ac.	Corn Ton/Ac.	Grass Hay (Other) Ton/Ac.	Grass Pasture Aum/Ac.	Orchards Bu/Ac.	Spring Grain Bu/Ac.	Sorghum Cwt/Ac.	Vegetables Ton/Ac.	Winter Wheat Bu/Ac.
10-02	6.0	20.0	4.53	-	-	-	-	-	-
11-16	1.12	-	0.73	-	-	-	-	-	-
11-22	-	-	0.65	-	-	47.6	-	-	26.66
12-02	2.97	23.9	1.56	-	400.0	-	-	10.0	-
12-03	2.21	23.48	-	-	400.0	-	-	10.0	-
12-05	1.22	-	0.93	-	-	42.16	-	-	-
12-06	1.05	-	-	-	-	29.53	25.00	-	17.92
12-08	3.02	-	-	-	400.0	-	-	10.0	-
12-13	2.16	23.9	-	-	-	-	-	-	-
12-15	2.00	-	-	3.03	-	10.46	26.00	10.0	-
12-16	-	-	1.90	-	-	-	-	-	-
13-01	-	-	1.09	-	-	-	-	-	-
14-01	2.63	19.13	-	-	-	47.38	-	10.0	-
14-02	2.37	19.6	-	-	-	-	-	10.0	-
14-03	3.52	-	-	-	-	-	-	-	-
14-04	1.57	16.67	-	-	-	23.88	-	10.0	-
14-06	1.74	16.13	-	-	-	-	14.10	10.0	-
14-07	1.34	15.44	-	-	-	-	38.14	10.0	-
16-07	-	-	0.65	-	-	26.3	-	-	-
17-01	1.01	-	-	-	-	-	26.01	-	26.83
17-02	1.84	16.01	-	-	-	34.26	23.43	10.0	-
17-03	1.29	16.16	-	-	-	-	39.28	-	-
17-04	1.86	18.20	-	-	-	-	-	10.0	-
17-05	1.35	18.20	-	-	-	-	-	10.0	-
18-07	2.16	-	1.03	3.35	-	26.3	-	-	29.10
19-15	0.80	-	-	-	-	-	37.22	-	28.70
67-01	2.49	15.90	-	-	-	-	67.51	10.0	45.10
67-02	3.25	-	-	-	-	65.57	55.61	-	-
67-03	2.29	17.34	-	-	-	13.44	69.82	-	60.06
67-04	2.18	15.90	-	-	-	12.31	68.70	-	45.17
67-05	2.18	15.90	-	-	-	-	38.10	10.0	-
67-06	2.21	16.30	-	-	-	16.18	68.85	-	48.50
Total Yield - Ac. X Yiels/Ac.	Ton 232,578	Ton 758,969	Ton 15,183	AUM 2,480	BU 239,600	BU 448,763	CWT 1,640,175	Ton 123,530	BU 88,886

Table B-9 (con't)

	EQ						OSE
Component	Water and Land Quality		Biological Measures			Visual Characteristics	Job Creation or Loss Project Construction
System No	Salt in Return Flows and Ground Recharge Tons	Prime Agr. Lands with Full Water Supply Ac.	Wetland Ac.	Phreato-phytes Ac.	Cotton Woods Ac.	Land Irrigated Ac.	(Total unskilled and semiskilled Labor) job/yrs
10-02	11,656	961	0	40	0	3,000	0.04
11-17	720	0	0	0	0	2,000	0.12
11-22	674	0	4	6	0	2,600	0.02
12-02	6,258	1,785	20	0	0	3,350	1.06
12-03	1,094	851	5	0	1	1,107	0.26
12-05	1,425	15	30	0	0	180	0.10
12-06	931	45	11	1	0	300	0.02
12-08	2,967	800	0	0	3	800	0.78
12-13	364	76	0	0	0	187	0.85
12-15	7,454	678	45	16	0	2,509	0.19
12-16	662	0	0	0	0	250	0.72
13-01	263	0	4	1	0	1,000	0.00
14-01	84,666	14,380	0	0	0	18,500	6.03
14-02	21,849	3,360	50	0	0	6,000	1.61
14-03	391	86	0	0	0	235	0.00
14-04	854	0	0	0	0	876	0.03
14-06	27,601	0	9,838	155	233	35,525	2.69
14-07	5,506	0	0	0	0	6,131	0.41
16-07	256	0	0	0	0	500	0.10
17-01	3,948	0	0	6	13	5,596	1.09
17-02	365,044	12,247	2,047	335	98	77,376	5.36
17-03	77,189	0	2,553	486	188	9,741	1.18
17-04	75,049	3,680	91	9	7	5,600	3.30
17-05	135,914	7,650	40	0	10	12,750	3.12
18-07	318	0	0	0	0	225	0.12
19-15	6,897	83	0	0	0	1,905	0.26
67-01	58.362	1,881	0	29	3	3,750	0.95
67-02	121,084	1,651	206	149	93	25,145	1.50
67-03	22,483	2,351	1	13	4	4,790	0.34
67-04	1,744	388	0	2	0	718	0.12
67-05	176	0	17	0	10	3,000	1.33
67-06	49,122	2,939	200	2	4	5,963	1.06
Total	1,092,921	55,907	15,162	1,250	667	241,605	34.76

1/ Costs were amortized at 7 1/8% for 25 years. 1980 prices were used for costs and benefits.

GPO 835-604

APPENDIX C - GLOSSARY OF TERMS

Amortized: The extinguishing of a financial obligation in equal installments is called amortization. The amortization factor is the amount of the installment required to retire a debt of $1.00 in a given length of time at a given interest rate.

Annual Crop Production Benefits: Increase in net returns (without project costs) derived by increased crop yields, acreage changes, and/or decrease in production costs.

Annual Installation Cost: Expenditures for initial construction of the resource improvement. These costs will include estimates for construction and may include engineering services, land rights, project administration and legal fees. These costs are then amortized to yearly equal payments.

Annual Man Year: Work produced by one person working eight hours per day and 250 days per year.

Annual Operation and Maintenance Cost: These costs represent the values of materials, equipment and services needed to operate the resource improvement, and to make repairs and replacement necessary to maintain the facilities in sound operating conditions during their economic life.

Blowing Snow Management: The use of fences or other features for the purpose of trapping or accumulating additional snow depth.

Canal Clearing: Removing vegetation from canal banks, berms, spoil and associated areas.

Canal Control Structures: Structures in an irrigation canal system that convey water, control the direction or rate of flow, or maintain a desired water surface elevation.

Canal Lining: A fixed lining of impervious material installed in an existing or newly constructed irrigation canal.

Canal Pipelines: A pipeline and appurtenances in an irrigation canal system.

Canal Seepage: That part of diverted or reservoir water that seeps into the ground water system. Some of this seepage may surface in drains, etc. and become surface return flow.

Canal Systems: Conveyance system and irrigated cropland served by the system.

Construction Cost: Construction Cost is the engineers cost estimate of the project plus 15 percent added for contingencies.

Consumptive Irrigation Requirement: Often abreviated CIR, which is the depth of irrigation water, exclusive of precipitation, stored soil moisture or ground water, that is required consumptively for crop production.

Conveyance System: A permanent irrigation canal or lateral constructed to convey water from the source of supply to one or more farms.

Cost Effective Crop: A crop which indicates a positive net benefit after all project costs are considered.

Critical Water (Sheet & Rill) Erosion: The rate in tons per acre of sheet and rill erosion that exceeds the soil loss tolerance value or the permissible soil loss for any given soil.

Critical Water (Gully & Streambank) Erosion: The tons of land erosion that is occuring within a defined channel 1 foot or greater in depth.

Crop Consumptive Use: The amount of water used by crops in transpiration and building of plant tissue, evaporated from adjacent soil, and intercepted precipitation on the plant foliage.

Diversion Structure: A structure built to divert part or all the water from a river or a stream into a different water course or irrigation canal or ditch.

Economically feasible: A condition when the ratio of average annual benefits to average annual costs meets or exceeds a specified value.

Economic Data: Generally refers to cost, returns, and benefits data.

Employment Benefits: Jobs and/or dollar wages created through some sort of project action.

Engineering Practices: These are structures which are designed, constructed and used in a soil and water conservation or management system to retain, regulate or control the flow of water.

Engineering Services: Engineering Services are 14 percent of construction costs.

Environmental Practices: Conservation practices which improve the environmental quality.

Environmental Quality (E.Q.): The creation, management, or preservation of areas of natural beauty, quality of water, land and air, biological resources and ecosystems, geological, archealogical, and historical resources.

Farm Control Structures: A structure in an on-farm irrigation system that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation.

Farm Ditch Lining: A fixed lining of impervious material installed in an existing or newly constructed irrigation ditch.

Farm Pipeline: A pipeline and appurtenances in an on farm irrigation system.

Floodplain Land Damage: The land damaged by sediment from the sheet, rill, gully and streambank erosion within the hydrologic area.

Full Water Supply: Croplands that have sufficient water to meet their needs.

Ground Water Recharge: Canal seepage and on-farm percolation of water into the ground in excess of soil moisture storage.

Historical Diversions: That amount of water turned into a conveyance system over some past period of time.

Hydrologic Area: Land areas that contribute runoff to a specified stream system.

Irrigation Efficiencies: The percent of water diverted that is consumptively used by crops. This is a combination of conveyance efficiency and on-farm efficiency.

Irrigation Shortage: An amount of water needed but not available to crops.

Irrigation Surplus: An amount of water surplus to crop needs.

Irrigation Water Management: Irrigation Water management means controlling or regulating water application in a way that insures high crop yields without wasting water, soil, or plant nutrients. It means applying water according to crop needs in amounts that can be held in the soil available to crops and at rates consistent with the intake characteristics of the soil and the erosion hazard to the site.

Installation Cost: Installation cost is the total cost of contruction engineering services, project administration and land rights.

Land Leveling: Reshaping the surface of irrigated land to planned grades.

Land Voiding: The acres of land area that is lost to gully and streambank erosion.

Linear Programming Techniques: A mathematical technique designed to maximize something (usually profit) or to minimize something (usually costs) subject to a set of limitations such as land, water, etc.

Maximize Net Return (Income): To combine a set of variables (such as resources) in amounts that would produce the maximum achievable net income.

Model: A mathematical formulation such as linear programming water budgeting, etc.

Net Annual Benefits: Increase in annual gross returns less annual costs including the annual costs incurred from some action (such as a project) as resulting from the action taken.

Net Return: Gross returns from production less production costs.

On Farm Drainage: A conduit, such as the tile, pipe or tubing installed beneath the ground surface to collect, and or convey drainage water.

On Farm Irrigation System: A planned irrigation system where all necessary water control structures have been installed for the efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

On Farm Return Flows: That part of applied irrigation water that returns to a stream channel or to the ground water system.

Partial Water Supply: Croplands that do not have sufficient water to meet their needs.

Prime Land: Available land that has the best physical and chemical characteristics for producing food, feed, forage, or fiber.

Production Values: Gross returns from production.

Project Administration Costs: Project administration cost is 17 percent of the construction cost.

Project Benefits: Benefits resulting from increased production and employment as a result of a project. Benefits may be primary as a result of the project, or secondary, being induced by the project in other areas of economic activity.

Project Cost: Total and/or annual amortized costs associated with project construction. It can also include annual operation and maintenance costs.

Project Feasibility: Projects which display a 1/1 benefit cost ratio or greater. In some cases projects can have a lower than 1/1 benefit cost ratio if other benefits such as employment or environmental considerations can be demonstrated.

Reduced Interruption of Irrigation Services: To protect conveyance system from breach or failures that would prevent irrigation water from reaching the farm.

Reservoir Water: Irrigation water turned into the conveyance system from reservoir storage. This water is supplemental to diverted water. Is shown as "Other water" also.

Return Flows: This includes on farm return flows and canal seepage.

Revised Present: This is a linear programming run which allows for upward and downward shifting in cropping patterns without project action. The purpose of this run is to make a better comparison with project alternatives which allow for some shift in cropping patterns rather than to compare with present condition which does not allow a present condition shift.

Salinity Levels: Concentration of total disolved solids in milligrams per liter.

Seasonal Evaporation From Reservoirs: Evaporation from water surface areas in Reservoirs for the season, April through October.

Semi-Skilled Labor: Labor which requires some skill but generally requires no special training or apprenticeship.

Short Water Supply: Same as partial water supply.

Soil Association: A mapping unit used on general soil maps in which two or more defined taxonomic units, occurring together in a characteristic pattern are combined on the map into one unit. The components of the soil association may or may not be contrasting.

Unskilled Labor: Generally applies to manual and surveilance jobs which do not require a special skill or training.

Upland Habitat Management: Retaining, creating, or managing area other than wetland for food and shelter for wildlife.

USLE: Universal Soil-Loss Equation - an empirical formula used as a means of estimating soil loss and evaluating conservation alternatives on a quantative basis. The equation is used primarily for predicting sheet and rill erosion on non-irrigated land and does not account for gully erosion and does not calculate sediment yield.

Water Budget Analysis: An accounting of water diversions, uses, and return flows.

Water Deficit: Same as irrigation shortage.

Water Surplus: Same as irrigation surplus.

Wetland: Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.

Wetland Habitat Management: Retaining, creating, or managing wetland habitat for wildlife.

Yields: This refers to crop yields in terms of units per acre. Units consist of such measures and bushels, hundredweight and tons.

APPENDIX D - SELECTED REFERENCES

Analysis of Colorado precipitation, by Marie Kuo and Stephen K. Cox, Colorado State University

An Approach to Water Resources Evaluation of Non-Point Silvicultural Sources. A Procedural Handbook. Published by U.S. Environmental Protection Agency EPA 600/8-80-012

Annual Operating Plan, Frying Pan-Arkansas Project 1979-1980 USDI-W&PRS, April 1980

A Plan for the Development, Use and Conservation of the Resources of the Arkansas Basin in Colorado, Arkansas-White-Red Basins Inter-Agency committee October 1953

Arkansas River and Tributaries, Las Animas, Colorado, and Vicinity - Letter from the Secretary of the Army July 2, 1943, 89th Congress, 1st Session House Document No. 165 May 11, 1965

Arkansas Valley Water Management program by USDA Soil Conservation Service

Arkansas-White-Red Basins
    Inter-Agency Committee Reports
        Part II
        Section 2 - Water Resources Project Data, Volume A, 1955
        Section 5 - Drainage 1955
        Section 6 - Irrigation and Reclamation 1955
        Section 8 - Domestic and Industrial Water Supply 1955
        Section 11 - Agriculture 1955
        Section 17 - Availability USE, and Control of Water 1955

Century II: A Plan for the Arkansas Valley Region of Colorado, October 1967, Colorado State Planning Office

Basic Land Information Storage and Retrieval System. A Course Description and Set of Instructions. State and Private Forestry, Region 2, U.S. Forest Service, Coryell A. Ohlander, 1979.

Climates of the States - Colorado by U.S. Department of Commerce Environmental Science Service Administration

Colorado Agriculture Data (SRG-8) McGrail, March 1980 (Computer Printout)

Colorado Agriculture Statistics by Colorado Department of Agriculture

Colorado Census of Agriculture by U.S. Department of Commerce - Bureau of Census

Colorado - Ground Water Basic-Data Release No. 21 - Hydrogeologic Data for the Lower Arkansas Valley, Colorado by Thomas J. Major, R. Theodore Hurr and John E. Moore, USGS 1970

Colorado - Ground Water-Basin Data Report No. 3, El Paso, County - Fountain, Jimmy Camp and Black Squirrel Valleys by Edward D. Jenkins, USGS 1962

Colorado - Ground Water-Basic Data Report No. 1, Prowers County by Paul T. Voegeli Sr., and Lloyd a. Hershey, USGS 1960

Colorado - Ground Water-Basic Data Report No. 12, Big Sandy Creek Valley in Lincoln, Cheyenne and Kiowa Counties, Colorado by Donald L. Coffin, USGS 1962

Colorado - Ground Water-Circular No. 10, Effects of Water Management on a Reach of the Arkansas Valley, La Junta to Las Animas, Colorado by E. A. Moulder, C. T. Jenkins, J. E. Moore and D. L. Coffin, USGS 1963

Colorado - Water Resources-Circular No. 27, Reservoir Release Routing Model for the Upper Arkansas River Basin of Colorado by Richard R. Luckey and Russell K. Livingston, USGS 1975

Colorado - Water Resources-Circular No. 31, Artificial - Recharge Experiments in the Alluvial Aquifer South of Fountain, El Paso County, Colorado by O. James Taylor, USGS 1975

Colorado Ground-Water Water Trends, Engineering Research Center, Colorado State University, (ER 72-73JAB32) by John A. Brookman

Comprehensive Listing and Categorization of Local Water and Sewer Needs, Colorado by Paula Herzmark, Executive Director Department of Local Affairs, Monte Pascoe, Executive Director Department of Natural Affairs, Dr. Frank Traylor, Executive Director Department of Health

County and City Data Book, 1962, 1972, 1977, 1980 - U.S. Department of Commerce, Bureau of Census

Final Report on Land Ownership and Land Use-Present, Past and Future Irrigation, by Colorado Land Resources Subcommittee to State Coordinator for Colorado - Arkansas-White-Red Basins July 21, 1952

Guide to the Geology of Colorado published by Geological Society of America, Rocky Mountain Association of Geologists, Colorado Scientific Society 1960

Irrigation Guide for Southeastern Colorado, Arkansas River Watershed Below 7,000 feet, USDA-SCS, August 1960

Irrigation Water Requirements - Technical Release No. 21 by USDA Soil Conservation Service

Monthly Normals of Temperature, Precipitation, Heating and Cooling Degree Days 1941-70 by U.S. Department of Commerce, National Oceanic and Atmospheric Administration

National Range Handbook by USDA, Soil Conservation Service

Physiography of Western United States, 1937 by Nevin M. Fenneman

Predicting Rainfall Erosion Losses - Agriculture Handbook No. 537, December 1978 by USDA Science and Education Administration

Public Domain Lands - Arkansas-White-Red River Basins - Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, Oklahoma and Texas, USDI-BLM 1961

Public Water Supplies of Colorado 1959-60 by USGS in Cooperation with Colorado State University Agricultural Experiment Station - General Series 757, June 1961

Report of the Hydrologic Subcommittee on Water Availability and Quality in the Arkansas-White-Red Basins, January 1951 by Arkansas-White-Red Basins Interagency Committee

Report on Review Survey for Flood Control and Allied purposes, Arkansas River and Tributaries Above John Martin Dam, Colorado. Volumn 1 - Main Report, Appendix E, F, G and H by U.S. Army Corps of Engineers

Salinity in the Arkansas Valley of Colorado by Donald L. Miles, Cooperative Extension Service, CSU May 1977

Sangre De Cristo, Plan of Action, USDA 1976, Resource Conservation and Development Project

Snow Control with Road Design and Snow Fences. Outline of presentation at the Snow Removal and Ice Control Technical Institute, University of Wisconsin, October 13-14, 1981 by Ronald D. Tabler

Soils of Colorado, Colorado State University Experiment Station, Fort Collins, Bulletin 566S in Cooperation with the Soil Conservation Service, USDA, R.D. Heil, D.S. Romine, D.C. Moreland, R.K. Dansdill, R.H. Montgomery, J.E. Cipra, July 1977

Soils of Colorado, Loss Factors and Erodibility and Hydrologic Groupings 1979 by USDA, Soil Conservation Service

Specific Problem Analysis Summary Report 1975 Nation Assessment of Water and Related Land Resoures, Prepared by Comprehensive Planning Committee, Arkansas-White-Red Basins Inter-Agency Committee, June 1977

Summary Appraisals of the Nation's Ground Water Resources - Arkansas-White-Red Region, Geological Survey professional paper 813-H, by Bedinger, M.S., Sniegocki, R.T., 1976

Ten Rivers in Americas Future - The Report of the President's Water Resources Policy Commission - Volume 2, 1950

The Upstream-Downstream Controversy in the Arkansas-White-Red Basins Survey, 1960 by Irving K. Fox and Isabel Picken

Thirty-Second Annual Report of the Upper Colorado River Commission

Universal Soil Loss Equation, Technical Note 50 (Revised January 1977), by USDA, Soil Conservation Service

Water for Tomorrow - Colorado State Water Plan - Phase 1 - Appraisel Report, Bureau of Reclamation in Cooperation with the State of Colorado February 1974

Water Legislation Investigations for the Arkansas River Basin in Colorado, Volume 1, Summary Report - W.W. Wheeler and Associates, Woodward-Clyde & Associates, Consulting Engineers, September 1968

Water Management Studies of a Stream-Aquifer System, Arkansas River Valley, Colorado by O. James Taylor and Richard R. Luckey

Water Quality Survey of Arkansas River, November 1971 through June 972 by Gregory T. Misback, with Water Pollution Control Division

R0000 925454

R0000 925454